A HOLISTIC AND SYSTEMIC MODEL OF COLLABORATION IN THE AEC INDUSTRY

Thesis submitted in accordance with the requirements of the
University of Liverpool for the degree of Doctor of Philosophy

By

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DECLARATION

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ABSTRACT

The Architectural-Engineering-Construction (AEC) industry is currently undergoing changes in digitalisation aimed at improving the information development and transfer between stakeholders. The changes in delivery required for digitalisation e.g., implementation of Building Information Management (BIM), is systemic. Barriers to implementing BIM and several project success factors are human centred. In the construction management, less importance is given to integrated processes and collaborating people when compared to the technical aspects. According to scholars, academic knowledge regarding factors affecting collaborating people is fragmented. Additionally, there is a difference between academic knowledge and the actual needs of practice.

The aim of this research is to understand the factors affecting project level collaboration and effective digitalisation by application of theory and reflection on knowledge interpreted from practitioner experience. By adopting a holistic perspective of reality, the thesis raises some core issues about AEC industry practice. The thesis therefore asks the question; *What could enable efficient project level collaboration and implementation of digitalisation in the AEC industry?*

The 'CIFE Horseshoe Framework' was used to guide the multi-disciplinary research approach. Data was collected from semi-structured interviews with a Project Management (PM) firm in Finland and focus groups with AEC firms in Norway. The analysis of the data was validated with five expert semi-structured interviews from the UK to ensure that the interpretation of data was consistent with industry practice. Thematic analysis was used to identify, analyse and report patterns within qualitative data.

The research combines approaches and knowledge from psychology, complexity science, sociology and business to induce understanding of current collaborative practice. A holistic model of project level collaboration was developed that placed factors from Human Psychology and Culture (HP&C) at the foundation of factors from AEC practice.

The development of the model contained in this thesis facilitates a more holistic understanding of practice and therefore, it enables the theoretical application from psychology on the client driven and contract inflicted biases in decision-making. Furthermore, it enabled reflection on digitalisation in relation to collaborative practice; suggestions on the way industry could enable better collaboration and more efficient implementation of digitalisation. The holistic understanding also enabled the combination of multiple influences on practitioner motivation from their organisation, the client, project social climate and standard contracts.

In conclusion, knowledge from actual practice has been interpreted to induce a holistic model of project collaborative practice. It shows that changes in practice (e.g., driven from digitalisation) must consider the social and psychological capability and expectations of people. Furthermore, the developed model provides a way to bring together multiple concepts in a structured manner by connecting various concepts representing reality, that appear fragmented in academic literature.

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CURRENT LIST OF PUBLICATIONS

Peer Reviewed Journal Paper:

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LIST OF ABBREVATIONS

Acronym	Full Version
2D CAD	Two Dimensional Computer Aided Design
3D CAD	Three Dimensional Computer Aided Design
AB	Association Based
AEC	Architectural-Engineering-Construction
BIM	Building Information Management
BIMM	Building Information Management Model(s)/Modelling
BLC	Building Lifecycle
CDBB	Centre for Digital Built Britain
CHAT	Cultural Historical Activity Theory
CIFE	Centre for Integrated Facility Engineering
CM	Change Management
CRM	Customer Relationship Management
CSR	Corporate Social Responsibility
CV	Curriculum Vitae
D & B	Design and Build
DBB	Design Bid and Build
FM	Facilities Management
HFI	Human Factors Integration
HMC-AEC	Holistic Model for Collaboration in the AEC industry
HP&C	Human Psychology and Culture
ICE	Integrated Concurrent Engineering
IDDS	Integrated Design and Delivery Solutions
IL	Information Latency
IPD	Integrated Project Delivery
ORQ	Overall Research Question
PB	Psychophysical Based
PBION	Project Based Inter-Organisational Network
PLC	Project Level Collaboration
PL	Project Lifecycle
PM	Project Management
PO	Professional Organisation
QI	Quantitative Instrument
ROI	Return on Investment
RQ	Research Question
SC	Sub-Contractor
SCM	Supply Chain Management
SRQ	Sub-Research Question
TSS	Transdisciplinary Sustainability Science
VDC	Virtual Design and Construction

1. INTRODUCTION

1.1 Research Context

The Architectural-Engineering-Construction (AEC) industry is currently undergoing changes in the way it operates driven by digitalisation of information exchange between stakeholders. The nature of these changes are increasingly systemic, meaning that they require multiple firms to change the way they operate (J. Taylor, 2005). Since the AEC industry involves exchanges between many types of professionals to create interdependent value, this makes project level collaboration increasingly important. Collaboration is the active and ongoing partnership between people from different backgrounds who aim to solve problems or provide services (Strype et al., 2014a). Within the context of the construction industry means adding that project level collaboration is interorganisational as teams from various firms are contracted to provide an interdisciplinary solution that meets the clients' needs.

The AEC industry is characterised by disjointed relationships between teams, misaligned objectives and risk averse behaviours (Rahman and Kumaraswamy, 2008). The adversarial business environment is said to be a major barrier to growth and diffusion of innovation (Andersen et al., 2004). The need for cultural change within project teams is crucial to ensure improvements in project level collaboration (Cheung and Rowlingson, 2005). Scholars do not appear to completely understand the reasons behind the adverse nature of the industry and thereby a need exists to take a more holistic approach to understanding the problem (Phua, 2013).

In recent years, one of the main sources of innovation in the AEC industry surrounds the adoption of Building Information Management (BIM) which has resulted in a paradigm shift but nevertheless requires more integrated environments (Zhang and Wang, 2009). It is argued that BIM needs soft collaborative skills (Papadonikolaki and Van Oel, 2016) and although the United Kingdom (UK) mandated BIM in 2016, its implementation has been slower than expected (Thompson, 2017; Ghaffarianhoseini et al., 2017; Walasek and Barszcz, 2017). The industry is predominantly accustomed to exchanging 2D drawings and other documents standardised historically to a socially accepted industry wide format. With Building Information Management Modelling (BIMM), rich data is combined from various models that requires similar structure; it follows that greater interoperation is required. Software technologies are making it easier to change the combined models independently fuelling the fragmented and individualistic approach of the industry. This undermines the potential of avoiding changes using efficient interoperation early in the project process. The need for close interoperation makes consideration of collaborative factors vital.

In the Construction Management (CM) domain the Integrated Design and Delivery Solutions (IDDS) model (see Figure 1) focuses on the integration of collaborating people, combined processes and interoperable technologies. The IDDS model was developed as BIM

became more widely used worldwide, however one might argue that all the traits of an IDDS model still apply to the use of digital technology at any level. People from various disciplines need to work together and coordinate information (Owen et al., 2009). Hjelseth (2017) explains the literature gap in integrated processes and collaborating people, unlike most of the literature found in interoperable technologies, – shows that digital technology is still thought of as a tool rather than in an holistic manner as some would argue it should be with any systemic innovation (J. Taylor, 2005).

Figure 1 (right) shows the theoretical framework adopted for this study. The model reiterates the need to study collaboration based on all aspects; tools, processes and people interdependently; one affects the other and can provide insight across domains as indicated by the overlapping elements of the IDDS model. For this reason, the research contained in this thesis was designed to study what affects collaboration from the perspectives of practitioner who utilise the process and the tools using a social scientific methodology. The IDDS model is linked to the content and structure of the literature review (Chapter 2). The principle of reflection between people, process and tools ensures a holistic view is developed. Driven by the numerous emergence of people oriented phenomena, the literature review also explains theories behind decision making and social behaviour.

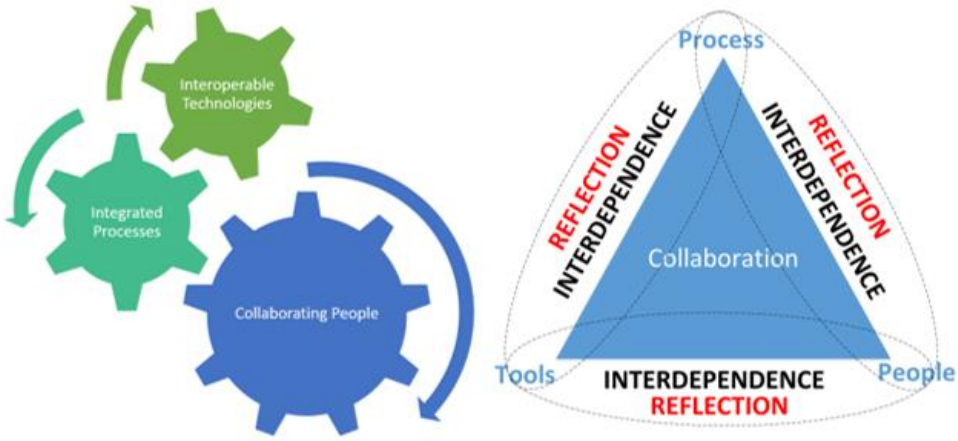


Figure 1 (Left): IDDS Model (adapted from Owen, et al. (2009)), Figure 1 (right): Collaboration Interdependence Model

A project's success in the AEC industry involves a significant number of human related factors (Chan et al., 2004), which represents the focal point of this thesis. The collaborative environment is one that is affected by several project related factors including ones relating to the individuals involved. To study project success, it is important to explore what fosters the optimal environment for people to cooperate and collaborate in order to have a successful project outcome.

The research's focus on collaboration and digitalisation aligns with politically driven changes in the UK AEC industry. In July 2013, Construction 2025 was released (Cable et al.,

2013) and shortly after, in April 2016, BIM was mandated (Thompson, 2017). The vision of the Construction 2025 report envisages the AEC industry as one that has resolved its negative characteristics; late delivery, cost overruns, commercial friction, late payments, accidents, unfavourable workplaces and an industry that is slow to embrace change (Cable et al., 2013).

Additional political driven change within the AEC industry associated with this research, is reflected in the UK's Digital Built Britain initiative, launched in October 2016. This seeks to digitise the entire lifecycle of the UK's built assets, going beyond the initial April 2016 mandate of BIM adoption to support its extension into higher levels of implementation. Building on Construction 2025, the Construction Sector Deal of July 2018 which is a subset of the UK government's modern Industrial Strategy launched in November 2017 (Government, 2017). The strategy identifies digital techniques as one of three strategic areas that:

> *'aims to transform the sector's productivity through innovative technologies and a highly skilled workforce' (Government, 2017, p. 6)*

More recently in 2017, the UK government established a Centre for Digital Built Britain (CDBB) to lead the next stage in the UK AEC industry's digital revolution to promote a move away from a focus solely on BIM (Neely et al., 2019); espousing an alternative perspective comprising of Design, Build, Operate and Integrate across the project lifecycle spectrum in order to stimulate transformation. In December 2018, Gemini Principles were published to outline a structured framework that enables effective information management across the built environment as a means to facilitate alignment of the diverse needs of multiple stakeholders (Bolton et al., 2018). An example of the implementation of such an approach is encapsulated within the Project 13 programme of May 2018 (ICE, 2018), promoted by the Institution of Civil Engineers (ICE), with a focus on infrastructure. This aims to move away from a traditional business model in the sector of project-based transactional relationships; a shift towards having greater investment in collaboration by focusing on innovation, relationships and skills which is predicted to bring improvements in productivity and deliver better value to construction clients and users. The political drivers all have a common objective of improving exchanges between people by implementing digital technology efficiently:

> *'Understanding the value and benefits that people and organisations seek… lies at the heart of this digital revolution… people's behaviour can provide an indication of the things they value… frameworks and models could help architects, engineers, social scientists and policymakers… to have a meaningful and auditable debate about the best outcomes and how to achieve them… making people's mental models explicit enables them to be discussed, shared and used by decision-makers' (Neely et al., 2019, p. 14)*

Mental models are unified representations of the perceived structure of a system and interactions within it (Doyle and Ford, 1998). The model and interactions between factors represent the researcher's perception of project level collaboration both from literature and practitioner experiences.

For this thesis, the aims, objectives and research questions are described in Section 1.2 (see below). The way that complexity and interdisciplinarity was managed is discussed in Section 1.3, and frames of reference used are presented in Section 0. An overview of the structure of the thesis is described in Section 1.4.

1.2 Aims, Objectives and Research Questions

The research gap is a lack of understanding in the application of people oriented phenomena in AEC project level collaboration (further described in Section 2.8). Therefore, the initial aim of the research was *to explore the current state of knowledge surrounding inter-disciplinary project level collaboration and develop methodology to suit the needs of practice and existing knowledge.* As the research progressed, the aim gained focus, facilitated by the development of the researcher's understanding from existing knowledge and practice accommodated by a practice-based exploratory study.

The overall aim was then established - ***to understand the factors affecting project level collaboration and effective digitalisation by application of theory and reflection on knowledge interpreted from practitioner experience.*** To meet this aim, research questions were developed (see Table 1). Sub-Research Questions (SRQ) 1 to 6 involved understanding collaboration and digitalisation from practical and academic knowledge. Whereas, SRQ7 to 10 uses this understanding to reflect on what could make the sector more efficient. The development of research questions evolved according to the change in researcher understanding of the needs of academic knowledge and practice, resulting in an unorthodox high number of research questions.

Table 1: Overview of Research Questions

Overall Aim Research Question	**What could enable efficient project level collaboration and implementation of digitalisation in the AEC industry?**	
Research Question	**Sub-Research Question**	
How can project level collaboration be studied? (RQ1)	**SRQ1**	Can project level collaboration be measured?
	SRQ2	What methodological paradigms are suitable to understand the reality of project level collaboration?
How do collaboration factors result in project level behaviour? (RQ2)	**SRQ3**	What factors affect project level collaboration according to project level practitioners?
	SRQ4	How can the factors that affect collaborative environments be visually interpreted?
	SRQ5	Which factors are most practical to change and impactful in driving industry wide change to suit project level collaboration and implementing digitalisation?
	SRQ6	How do expert views from literature and practice compare to project level views?
How could the AEC industry increase project level collaboration by efficient implementation	**SRQ7**	How are factors rooted in Human Psychology and Culture (HP&C) valued in the AEC industry compared to similar industries?

of digitalisation by comparing to similar industries? (RQ3)	**SRQ8**	How can AEC collaboration models be adapted to suit realistic nature of factors?
How could the AEC industry increase project level collaboration by efficient implementation of digitalisation by focusing on the transactional aspects (meso)? (RQ4)	**SRQ9**	How are the psychological and social aspects affecting project level decision-making and collaboration at the meso level?
	SRQ10	How is the meso level affecting the mentality of collaboration and implementation of digitalisation at the project level?

The following objectives were developed to answer the relevant research questions in order to effectively achieve the overall aim:

- To conduct a mixed methods study to validate and test a quantitative tool developed from intuition and literature from similar industries to assess project level collaboration (SRQ1),
- To outline a methodology which will enable understanding of project level collaboration holistically, incorporating technical, process and human factors (SRQ2),
- To visualise and comprehend empirical factors drawing out the most significant themes and factors using thematic analysis (SRQ3),
- To understand the factors that affect collaboration at the project level from empirical evidence (SRQ3),
- To understand the interactions of factors that affect collaboration at the project level from empirical evidence and literature to develop a general model from interactions (SRQ3 and 4),
- To develop a multi-level model that suits interactions between Human Psychology and Culture (HP&C), industrial and organisational, client, contractual and procurement and project level collaboration factors (SRQ4),
- To focus theoretical application and discussion at a level that is both practical and impactful (SRQ5),
- To validate the model and meso level centred empirical findings by the use of expert interviews and existing literature (SRQ6),
- To discuss the way that human factors are valued and used in similar industries (SRQ7 and 8),
- To discuss ways that the AEC industry can enhance project performance and collaborative behaviour by focusing on HP&C (SRQ8),
- To discuss the way that rooted psychological and cultural factors affect project level decision-making by focusing on empirical data collected surrounding the meso level (SRQ9),

- To discuss the impact of connections between the meso level and rooted HP&C factors at the project level (SRQ10).

1.3 Overview of Research Method

The research method was developed based on the crucial realism philosophical stance. This approach is committed to both the existence of an objective reality and the subjective knowledge of this reality (Kozhevnikov and Vincent, 2018).

To gain an in depth understanding of project level collaboration focus groups and semi-structured interview sessions were conducted. The practical knowledge from these sessions were interpreted using the sense-making process (Section 1.3.1) represented within frames of reference (Section 1.3.2).

1.3.1 Complexity and Interdisciplinarity

This section explains the role of sense-making and interdisciplinarity used to closely reflect on real-life practice. Using sensemaking of complex data collected using a social scientific method, a Holistic Model for Collaboration in the AEC industry (HMC-AEC) was developed. The HMC-AEC is structured using the frames of reference explained in Section 0. This model represents a holistic understanding developed for collaborative practice surrounding a digital environment. Additionally, it allows for the application of theories on decision making from psychology. The combination of psychology theory and social science methods is applied in Construction Management (CM) to provide a reflection close to industry practice.

Figure 2: Cynefin Framework showing Methodological Evolution (Adapted from McLeod & Childs, 2013)

The Cynefin framework (Figure 2) is a sense-making tool, not a categorisation tool. In a categorisation model, the framework precedes the data, but in a sense-making tool, the data precedes the framework (Snowden and Boone, 2007). The word 'Cynefin' signifies that 'multiple factors in our environment and our experience influence us in ways we can never understand' (Snowden & Boone, 2007: p. 2). The application of the framework is in numerous domains, it is used when understanding complexity is required to make decisions on the way to respond.

In this context, the Cynefin framework is used to assess the complexity of project level collaboration in order to apply relevant data analysis and collection techniques. The project started with an exploratory study which took a more reductionist approach described in further detail in Chapter 3. With understanding from literature and experience, quantitative and qualitative methods were used. The assumptions and understanding used in the exploratory study signified an underestimated complexity evident from the qualitative part of the study; unexpected interactions between phenomena made the researcher search for a sensemaking tool. In other

words, the cause and effect relationship was not simple, the effect on collaboration was from complex causes which depended on multiple phenomena interacting. The Cynefin framework therefore contributed to the analytical approach used in this thesis, in particular, adopting the distinct application of the sense-making process (see Section 4.7.2).

The high complexity meant that a methodological change was required; represented by the arrows in Figure 2, the blue arrow is representative of the exploratory study and the purple arrow shows the main study. In the exploratory study, based on the researcher's understanding and experience, a method fitting the 'simple' category (complexity assumed from literature and researcher knowledge at the time) was tested in a complex environment. On the other hand, as shown by the purple arrow, the methodology was changed to suit the uncertain complexity as defined in the Cynefin involving a sense-making process. By studying collaboration in a semi-structured qualitative approach in multiple industries, a model was developed to structure the data collected to make sense out of the complex phenomena. The methodology of the main study is described in further detail in Chapter 4.

The complicated and complex quadrants (the purple arrow in Figure 2) of the Cynefin framework are most suitable to describe the interacting phenomena resulting in collaborative behaviour. The complex and complicated quadrants both have cause and effects that are not easy to see; for the complex quadrant it is more evident to experts and for the complicated quadrant it is more evident in retrospect (McLeod and Childs, 2013). To deal with the complexity of the research topic, an expert in forensic psychology was introduced to the supervisory team. Whereas, the sense-making approach was adopted in the analytical strategy to understand from retrospect, the causes of collaborative behaviour.

The research takes concepts from multiple disciplines and therefore involves interdisciplinarity. Klein (1990: p. 138) defines three types of interdisciplinarity:

- Multidisciplinary: more than one discipline used to work on the same problem with no real interaction between one another
- Pluri-disciplinary: interacting knowledge based on the progress made in each discipline
- Transdisciplinary: organising interdisciplinary research by using a unifying vision

In this research, transdisciplinary best describes the way concepts are used. The model (HMC-AEC) was developed based on interpretations made from experiences of industry practitioners and drove the way concepts were integrated. Concepts were applied from multiple disciplines to explain the interactions between phenomena in the HMC-AEC.

1.3.2 Frames of Reference

Commonly used in the Construction Management (CM) domain are the project lifecycle and building lifecycle frames. For the purpose of this research, the project lifecycle refers to the stages in a construction project from project conception to handover. Whereas the building lifecycle

represents all the stages of an asset from project conception to building demolition. The perspectives of the participants in this research are predominantly involved in the project lifecycle.

In many business contexts an external analysis model consisting of micro, meso or macro perspectives are used to structure complex information (Van Notten et al., 2003). In this thesis, the classification shown in Figure 3 was used for analysis and model development. Micro refers to the individuals from teams appointed by their individual firms working together on an AEC project. The macro represents a perspective of the wider industry from which the micro project teams come from. The meso refers to the transactional aspects; the way that the people from the industry (macro) are given responsibility in the project (micro). In the CM domain, a similar classification was used by Moum (2008) in studying designer collaboration further discussed in Section 2.2.3.

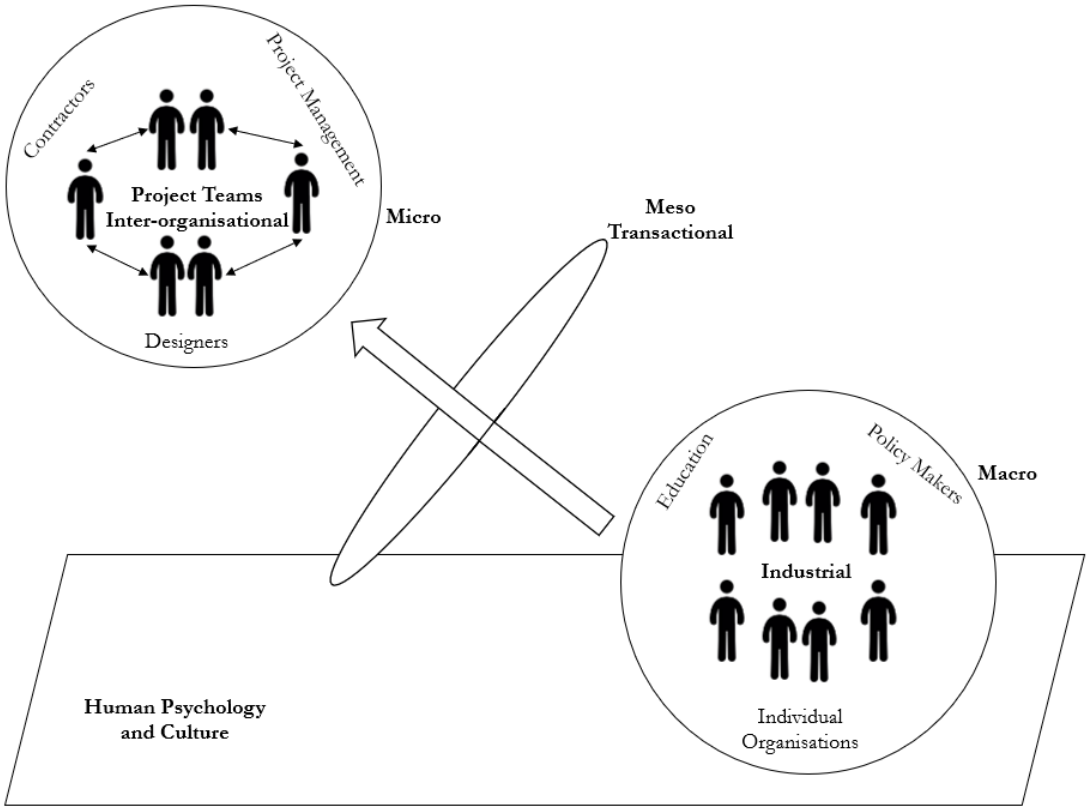


Figure 3: External Analysis Used in this Thesis

From the analysis and model development conducted in this research, an additional level was added to the external analysis logic. A foundational level called the Human Psychology and Culture (HP&C) was added as a result of the discovery of human oriented factors that were common in all micro, meso and macro perspectives.

1.4 Thesis Structure

CIFE Horseshoe Framework (Kunz and Fischer, 2008) developed by the Centre for Integrated Facility Engineering (CIFE) of Stanford University was selected as the guiding research framework because of its potential to structure a transdisciplinary research process. Figure 22 shows an overview of the thesis structure with respect to the research framework adopted.

The thesis is structured in a logical form, starting with the literature review (Chapter 2) where a review of relevant existing knowledge is presented. The exploratory study framed the researcher's understanding of collaboration in practice (see Chapter 3), which therefore influenced the methodology of the main study (see Chapter 4).

The results from the main study are interpretations of practitioner experience from the Norwegian and Finnish AEC industries presented in Chapter 5. The transfer of these empirical accounts into a generalised model by inducing general interactions between factors (Chapter 6) provides a holistic representation of the complexity of AEC collaboration practice. Since the analysis process depended on the researcher's understanding, in Chapter **Error! Reference source not found.** expert interviews and literature were used to validate the parts of the knowledge used for theoretical application. Chapter 8 uses the holistic perspective of knowledge acquired from practice to apply psychological theory, defragment practitioner motivation, suggestions to use technology more efficiently and compares the consideration of human factors to similar industries. Finally, Chapter 9 summarises the content of the thesis and provides the researcher's reflection and personal views to increase transparency of researcher bias.

2. LITERATURE REVIEW

2.1 Introduction

In this chapter, literature found relevant to answering the research questions in Section 1.2 are reviewed. The focus of this literature review is in the reflection between people, process and tools in relation to project level collaboration (as explained in Section 1.1). In other words, a holistic view was utilised to make connections between the topics presented in this chapter. This chapter is a crucial part of the methodology because it frames the researcher's understanding which was embedded in the analytical approach (see Section 4.5).

Project level collaboration (see Section 2.2) and digitalisation (see Section 2.2.5) in the AEC industry are described generally. The academic view of the way that the AEC industry delivers products and/or solutions to the client is explained in Section 2.4. The client is an important stakeholder in an AEC project making it important to understand and define their role (see Section 2.5).

Due to the emergence of the high importance of people oriented phenomena in the research, concepts from psychology and social science domains of literature used to understand and apply theory are presented in Section 2.6. Additionally, the Construction Management (CM) domain based studies on indicators of collaboration e.g., trust and motivation are described in Sections 2.6.6 and 2.6.7.

Taylor (2005) generalises the AEC industry like the film, health care, defence industries. To allow for key phenomena to be explored outside the CM domain, a comparison with the film industry was conducted (see Section 2.7.1). The use and application of human oriented aspects in practice in health care is shown in Section 2.7.2. The policy used to unite practitioner perspectives regarding human factors in the defence industry is described in Section 2.7.3. The aim of Section 2.7 is to enable an outside view from similar industries to the CM domain specific literature.

The identification of gaps in the knowledge is explained in Section 2.7.4. Section 2.9 summarises the chapter in relation to the research questions shown in Table 1.

2.2 Project Level Collaboration

This section aims to provide a general understanding of project level collaboration in the AEC industry according to the CM domain. Collaboration in reference to human factors is gaining importance in academia as described in a historical synopsis in Section 2.2.1.

An overview of project level collaboration is presented in Section 2.2.2 partly forming the understanding of the researcher from literature. A split in literature between design and construction is recognised in the literature; Section 2.2.3 introduces key literature in designer collaboration and Section 2.2.4 introduces contractor collaboration. The split in the literature is as a result of researchers describing design and non-design disciplines as two separate work environments with cultures and processes of their own (Singh et al., 2011), although there is logic

to the statement, the high dependency and complexity between the two worlds makes this simplification questionable. This interdependence between design and construction was the primary motivation of utilising both perspectives in gathering data to answer the overall research question.

2.2.1 Industry Historical Synopsis of Gathering Importance of Collaboration and Digitalisation

Throughout the twentieth century, team-based relationships were increasingly connected to the success of construction projects (Murray and Langford, 2008; Baiden and Price, 2011). Reform in the form of construction reports post Second World War to drive change in the industry were contributed to by multiple scholars e.g., Simon (1944), Emerson (1962), Banwell (1964). Changes in the industry were accelerated by the 'Constructing the Team' (Latham, 1994) and 'Rethinking Construction' (Egan, 1998) reports. This led to subsequent reports 'Rethinking Construction: Accelerating Change' (Egan, 2002) and 'Review of Skills for Sustainable Communities' (Egan, 2004). The Latham report explained that implementation of effective strategy begins with the client and claimed that contractual reform alone would not solve adversarial behaviour (Latham, 1994). The Egan reports suggested that the industry should focus on committed leadership, the customer, integrating processes and teams, a quality driven agenda and commitment to people (Egan, 2002). Additionally, 'Building Down Barriers' (Cain, 2003) was aimed at clients encouraging leadership and procurement of integrated teams therefore promoting the intangible aspects of construction projects. From these reports, the industry became aware of the importance of addressing collaboration, relationships and behaviour. Due to the UK AEC industry's significant contribution of 7% (£110 billion per annum) to the Gross Domestic Product (GDP) (Cabinet Office, 2011), the above reports were taken seriously at the national level (Murray and Langford, 2008).

Whilst the importance of human inter-team behaviour and collaboration were becoming increasingly apparent, the restricted nature of innovation became evident due to the fragmented nature of the AEC industry in the 1980s. As a result of the increased specialization driven by increasing project complexity, the industry became more fragmented to reduce and spread risk (Loosemore, 2013). As a result of the increasing complexity, fragmentation and awareness from reports, studies into the intangible aspects of the industry such as organisational culture and tacit knowledge began bringing about a change in the research's philosophical approach.

In short, the number of reports and changes in focus have resulted in the acceptance that AEC disciplines are highly interdependent and must collaborate efficiently to ensure measurable positive outcomes for clients and industry (Austin et al., 2007; Murray and Langford, 2008).

A recent report from the Centre for Digital Built Britain (CDBB) was developed by a large community of researchers and practitioners in the UK AEC industry (Neely et al., 2019). In reference to the focus of this thesis, it promotes the use of social science along with existing

approaches in understanding digitalisation and collaboration by explaining that there needs to be increased research in both stakeholder and lifecycle value.

2.2.2 Overview of Project Level Collaboration

A framework developed from an analysis of academic literature mapped managerial areas of BIM showing the need to consider the working environment fundamentally below process, tools and people (He et al., 2017). This study defines the working environment as one that enhances interoperability and claims that interoperability is technically focused on the current state of knowledge; this technical focus needs to be extended to cover business and social processes in creating collaborative project teams (He et al., 2017). The use of organisational climate concept as an indicator is suggested.

From supply chain management, low levels of collaboration between teams means supply chain participants share information and other resources to a minimum degree to meet common goals whereas high levels of collaboration means additionally having decision synchronization and incentive alignment (Huang, 2017).

The IDDS model (as introduced in Section 1.1) was developed as a grounded concept involving consultation with several hundred people around the world. Three parts of the model included collaborating people, integrated processes and interoperable technologies represented in a single level overlapping with IDDS in the centre (Owen et al., 2013). IDDS has had a significant impact in helping researchers and practitioners understand the complexity of the reality of collaborating using integrated processes and interoperable technologies. Additionally, its purpose is to develop new approaches to integrated design and to engender debate about the development of the industry. IDDS's definition of collaborating people, was utilised as a point of departure.

Collaboration and data exchange is still document-based in many projects (Rezgui et al., 2013; Shafiq et al., 2013; Volk et al., 2014). Lack of training and education is linked to inefficient collaboration (Arayici et al., 2011; Hannele et al., 2012; Becerik-Gerber et al., 2012; Bryde et al., 2013). The isolated use of digital technology is being overcome by developing collaboration standards (Isikdag and Underwood, 2010; Shen et al., 2010; Singh et al., 2011). Implementation of technologies as required by BIM are being hindered by social and institutional barriers further discussed in Section 2.3.3. The AEC and Facilities Management (FM) industry is widely acknowledged as resistant to change especially in employment patterns and processes (Lottaz et al., 2000; Rezgui et al., 2013; Shafiq et al., 2013; Volk et al., 2014) partly due to risks in liability, data security and interoperability (Gu and London, 2010; Eastman et al., 2011; Singh et al., 2011; Watson, 2011; Hannele et al., 2012; Volk et al., 2014). Willingness to collaborate and cultural differences is also suggested to be hindering unified use of digital technology (RICS, 2013). Even though the challenges are widely acknowledged, understanding of the hidden conceptual reasons for the barriers are lacking and almost non-existent in the CM domain, providing the motivation

and logic of developing the overall research question. Construction projects are challenging innovation because:

- There is variance in IT capability in teams (Panuwatwanich et al., 2008; Succar et al., 2012)
- Firms struggle to develop new ways of working and change the established practices (Howard and Björk, 2008)
- Firms fail to establish common infrastructure for BIM technology inter-organisationally (Ahuja et al., 2009)
- Many high level managers are sceptical about the business value of systemic innovation like BIM (Suermann and Issa, 2009)

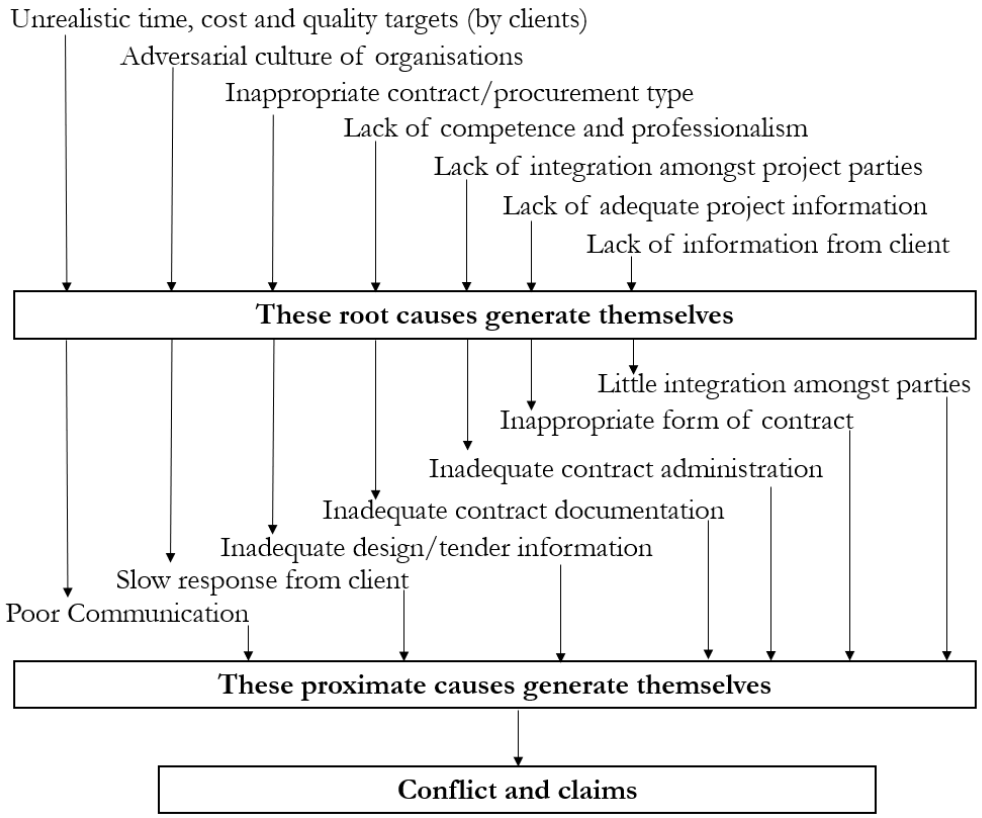


Figure 4: Root Causes of Conflicts and Claims (Redrawn from Craig & Sommerville, 2006)

Craig & Sommerville (2006) examines the drivers for the use of information management systems in the AEC industry and found that to improve operations a collaborative culture is needed so that all project participants have access to project information to address the root causes shown in Figure 4. The paper explains the need for major cultural changes and improvements communication, although, it does not go further in explaining the cultural changes needed.

2.2.3 The Designers' Perspective on Collaboration

Barrett (2018) studies designer collaboration using a psychological and social scientific approach utilizing focus groups after recognizing that the quantitative part of the study did not bring significant value. A key difference is that the author is an architect and a social psychologist thereby applying the norms of social psychology in their research investigation. From Barrett's study, it is suggested that within a project team, groups forms. These groups can be subdivided into ingroup or outgroup where the ingroup have more influence on decision-making than the outgroup. Other than this interesting observation, factors structured within the client, procurement etc. (as shown in Figure 5) all affect individuals differently and therefore the way that they behave towards one another (the rounded rectangles represent individuals). The factors have multiple agencies meaning that they vary from the perspective of the industry, discipline, company or an individual. Another key observation made was in the clashing extrinsic motivation (profit) and intrinsic motivation (learning new technology) in adopting project level innovation, this is further discussed in Section 2.6.6.

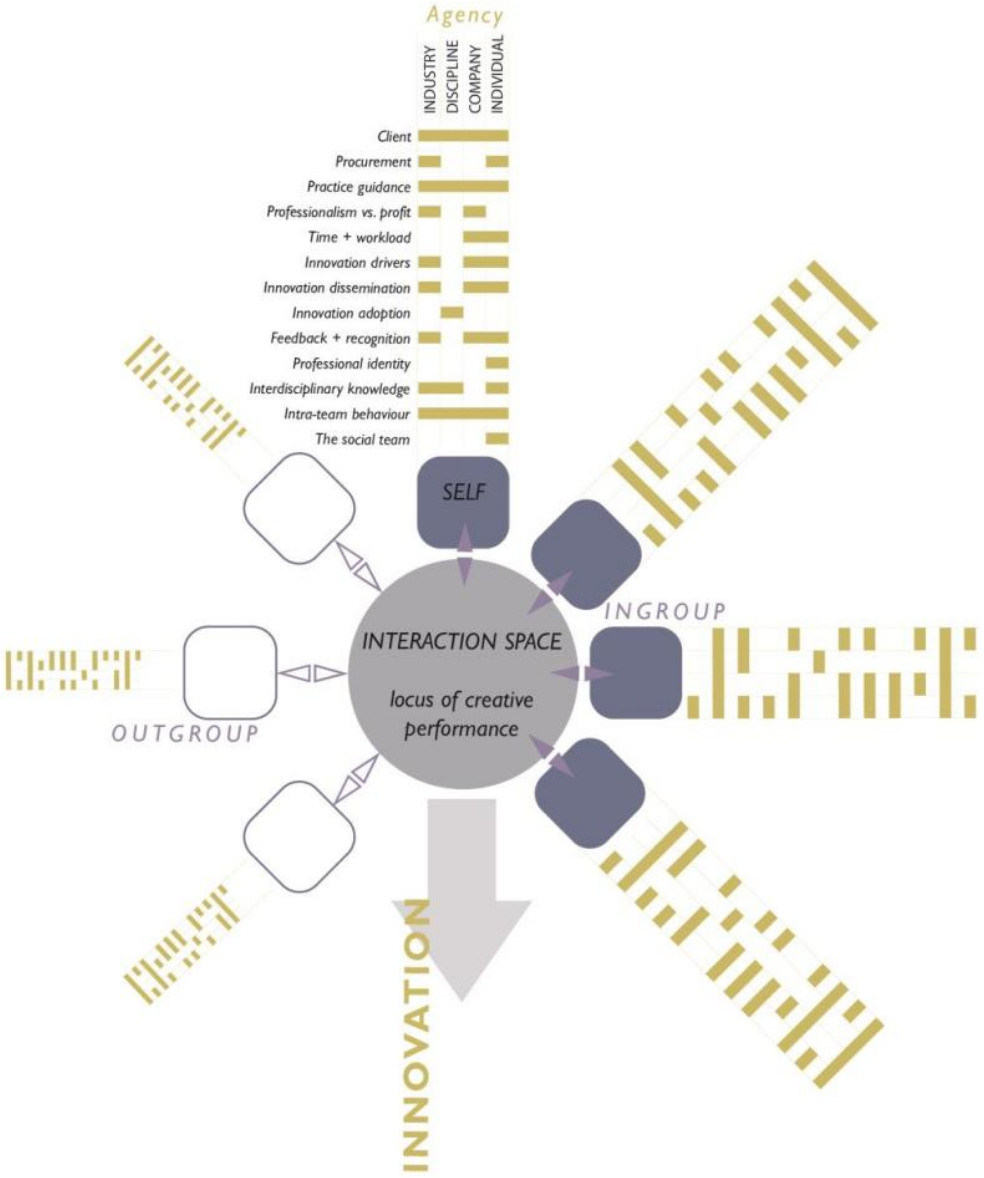


Figure 5: Social Psychological Framework of Designer Collaboration (With permission of Barrett, 2018)

Moum (2008) studied collaboration between designers, in a similar way to Barrett (2018). However, Moum (2008) uses a different approach to structure the hierarchical analytical approach using micro (individual architect/engineer), meso (transactional) and macro (group of teams from various organisations) in assessing case studies. Furthermore, the author also uses the CIFE horseshoe as a research framework. These two frames of reference are common with the analytical approach and methodology of this thesis. The approach's advantage is that it brings a flow of knowledge from practice to academia who need to gain knowledge of real-life practice (Moum, 2008). The author's contribution was in reflecting on 'established' practice using micro, meso and macro to structure the discussions.

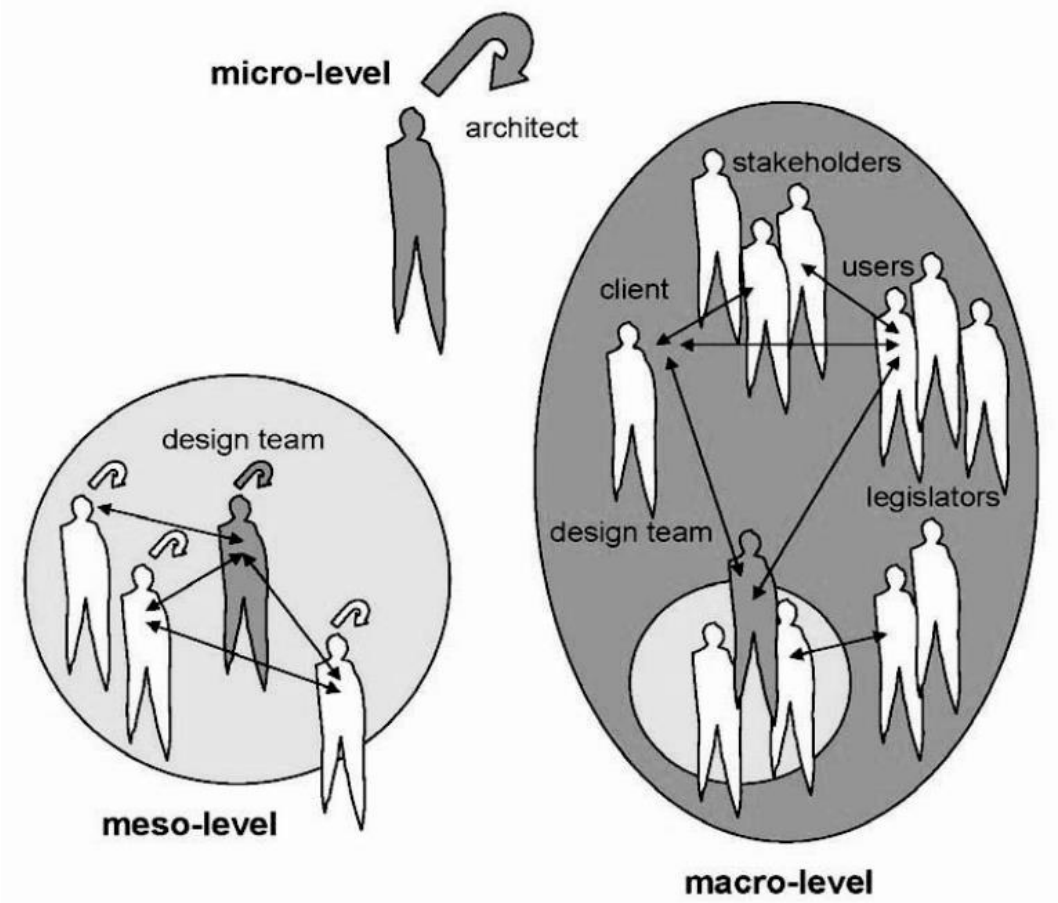


Figure 6: Moum's External Analysis Logic (Moum, 2008)

Putting creative people together does not necessarily result in creative solutions (Leonard-Barton and Swap, 1999). The design process is a social process of interaction and negotiation (Bucciarelli, 1994).

From observations in design practice, it is suggested that the effective management of the social processes within the team environment is linked to the success of the project's outcome (Murray and Langford, 2008). The longstanding focus in relation to human factors (in design) is in the individual and cognitive process (MacKinnon, 1965; Goldschmidt and Badke-Schaub, 2010; Rahimian and Ibrahim, 2011). Additionally, Pryke (2004, 2005) has explored design activity as a social and collaborative process by mapping social networks in projects.

Even though the awareness of the importance of collaborative behaviour is made clear over the past few decades, adversarial culture and relationships are still a current challenge (Loosemore, 2013; Elmualim and Gilder, 2014). Although positives from research and reports of the need to reform and change the industrial practice, the normative challenges suggest that reform has not substantially occurred; the behavioural attributes are still bringing about disputes and inefficiency. The literature suggests that human behaviour and collaboration is the product of complex information exchanges at the project level and other external factors that are not well understood (Alperen, 2016).

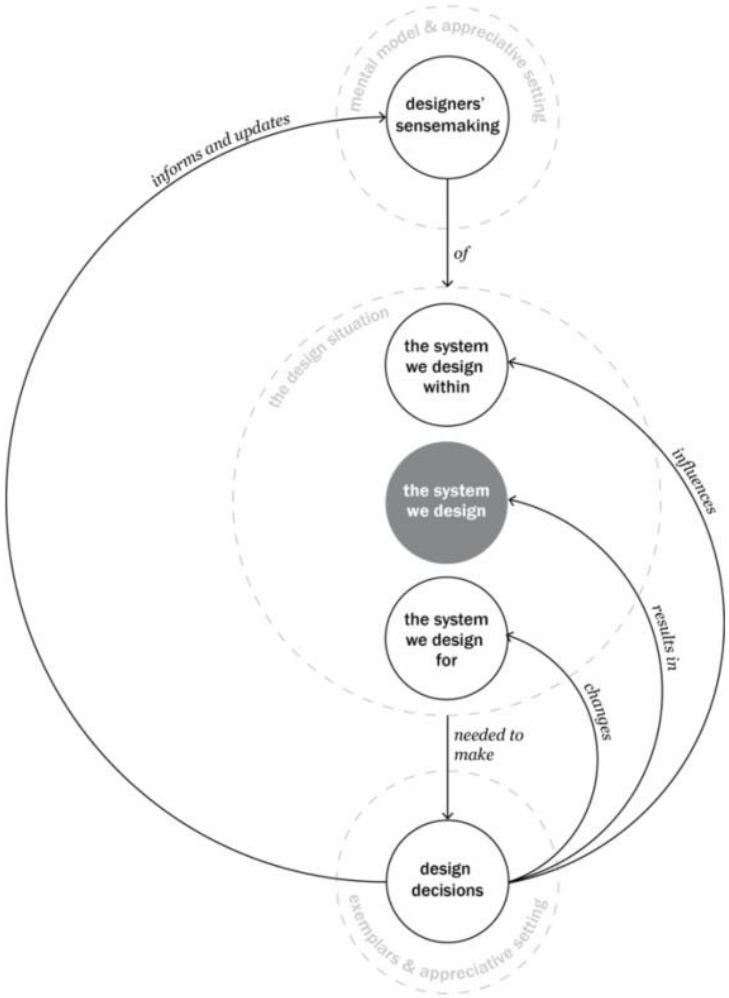


Figure 7: Luras' systems view of designer collaboration (with permission from Lurås, 2016)

On the basis of systems thinking (see Section 2.6.3), Lurås (2016) develops a distinct view to designer collaboration consisting of intertwined systems as shown in Figure 7 from the context of marine design. The relevance is due to the similarity in process of marine design and AEC design as they are both inter-disciplinary which involve interaction between various teams. Similar to the research presented in this thesis, the researcher uses sensemaking to develop the understanding of interacting systems. The author goes further to explain that the sensemaking process is also a part of the designer's understanding and decision making process, as the effect from the systems affect the decisions that are made.

The complexity of design decision making is made more explicit by showing that decisions affect interacting systems. These interacting systems applied in the AEC industry consist of:

- The system designed for: the wider context of the way the asset will be used represented by the interaction between the asset and the users
- The system the designers are designing: the asset's design

- The system the designers are designing within: the aspects that affect the practitioners' ability to do a satisfactory job

The systems interactions presented signify the interdependence of design decisions on multiple systems which are represented in this research as interactions in the adopted external analysis.

2.2.4 The Contractors' Perspective on Collaboration

Compared to the designers' view, literature available on collaboration between contractors varies from practice, selection criteria, performance, characteristics, barriers/obstacles and working conditions (Bemelmans et al., 2012). This area of research is different to the designers' perspective as there do not appear to be many people centred studies with application of psychological concepts, although many pieces of literature use a social scientific approach (e.g., surveys).

In a social scientific approach in studying the role of site managers in Finland, it was evident that the use of BIM was hindered by insufficient information content, lack of mobile devices and employee competency resulting in limiting the use of BIM to a few tasks (Mäki and Kerosuo, 2015). The use of BIM on site requires changes in activities and collaboration between designers and site management. The author calls for designers to learn to provide constructible designs and models whereas site personnel need to learn to build according to the designs rather than improvising; there is a dependency on the quality of the design solution which also depends on how they collaborate. Therefore, it is more valuable to research considering design and construction interdependently. Traditionally, the contractors have treated designs as an imperfect source of information (Styhre et al., 2006) possibly because of the differences in culture, use of traditional contracts and differences in market conditions. A study on collaboration from a contractor's perspective shows the top five factors that lead to willingness to collaborate (Rahman et al., 2014):

- Teams with the same local culture cooperate better
- Improved quality and timely project completion
- Enhanced service quality from suppliers
- Better communication among project members
- Encouraging teamwork from main contractor or project leadership

2.2.5 Summary of Project Level Collaboration

This section presents literature surrounding the state of the art perspectives surrounding project level collaboration split between designers and contractors. The reason for this split is because there is a difference in the way they work where design collaboration is more interdependent than contractor collaboration. Although, they also depend on one another and therefore formulates the view of considering both in this research as it would represent reality.

Designer collaboration is discussed in more detail than the contractor's perspective and numerous researchers simplify by making the split in focus. However, the IDDS framework's reflection between people, process and tools allows the argument that there is need to study

designer and contractor collaboration more holistically; they share tools, impact one another's roles and solutions. Therefore in the main body of this research, the decision was made to avoid the split between them.

2.3 Digitalisation in the AEC Industry

Information loss during the building lifecycle is studied and valued at $15.8 billion in the US AEC industry (Alan C. O'Connor, J L. Dettbarn, 2004). The cost is predominantly from the lack of useful information at the Facilities Management (FM) phase of the project; there is need for interoperability between systems and understanding of needs at each phase of the building lifecycle (Teicholz, 2013). The nature of innovation is systemic meaning that firms require to align their practice (J. Taylor, 2005). This makes the link between project level collaboration and digitalisation in the building lifecycle explicit; the solution at FM is dependent on earlier phases of a project.

An overview of the current state of digitalisation in the AEC industry is discussed in Section 2.3.1. Followed by the way disruptive technology is adopted (see Section 2.3.2) and the barriers to BIM exemplifying the number of people centred barriers (see Section 2.3.3). Information Latency (IL) is explained in Section 2.3.4 and is used to unite people and technology perspectives. The final part explains the need for performance metrics which was the point of departure for SRQ1 (see Section 2.3.5).

2.3.1 Current State of Digitalisation in the AEC Industry

Ecology is widely used in the construction management domain to describe the complex interactions of people and artefacts. Harty & Whyte (2009) takes a practice-based approach to examine changes in the industry as a result of the development of information technologies. Three different perspectives show the ways that people's mentalities are framed by the process that they work within; a switch to another form of coordination results in increasing complex ecology of people and objects referred to as a hybrid. E.g., Designer – drafter: the distinction in roles of the designer and the drafters persisted beyond the advent of 2D CAD. Even with 2D CAD, interactions between designer and drafter still involved paper. In summary this perspective showed that work methods are heterogenous distribution of practice where materials/tools are an add on to a human centred process. However, it is not acknowledged why this increase in complexity occurs.

Mahamadu *et al.*, (2019) justifies the role of organisational BIM capability in BIM delivery success. The author also shows the multi-dimensional nature of this relationship which has been predominantly perceived as a unilateral and technological concept. The study puts an emphasis on the roles of specific information delivery maturity, collective knowledge, skills and attitudes (process and human interactions). Considering the two studies described above, the maturity of use of digital tools can be perceived as getting its use incorporated into human routines and activities so that one can personalise and bring to themselves more psychological comfort.

Many project teams struggle with how to work based on new systemic innovation (Merschbrock and Munkvold, 2015). Many construction projects do not exploit the potential of BIM (Neff et al., 2010; Merschbrock, 2012; Leeuwis et al., 2013). The technology is constantly developing and is certainly available to use to substantially transform design and construction (Boland Jr et al., 2007; Berente et al., 2010). The changes are in the way information is coordinated (Neff et al., 2010; Whyte, 2011). Many barriers exist, individual, environmental and technological (Dossick and Neff, 2009; Neff et al., 2010). Many construction firms operate in 'siloed' environments instead of encouraging a more collaborative culture (Merschbrock, 2012).

Despite the potential of increasing productivity and the overall efficiency of construction projects by the use of BIM, the adoption of BIM has been slower than expected (Walasek and Barszcz, 2017). A Return On Investment (ROI) analysis showed that design fees would increase with BIM as a result in the increased workload during the earlier phases of a project (Walasek and Barszcz, 2017). On the other hand, the lack of evidence on ROI related to the use of BIM is identified as one of the barriers of its adoption by small to middle sized enterprises in the AEC industry (Hosseini et al., 2016; Li et al., 2019).

2.3.2 Changes to Practice to Facilitate Digitalisation

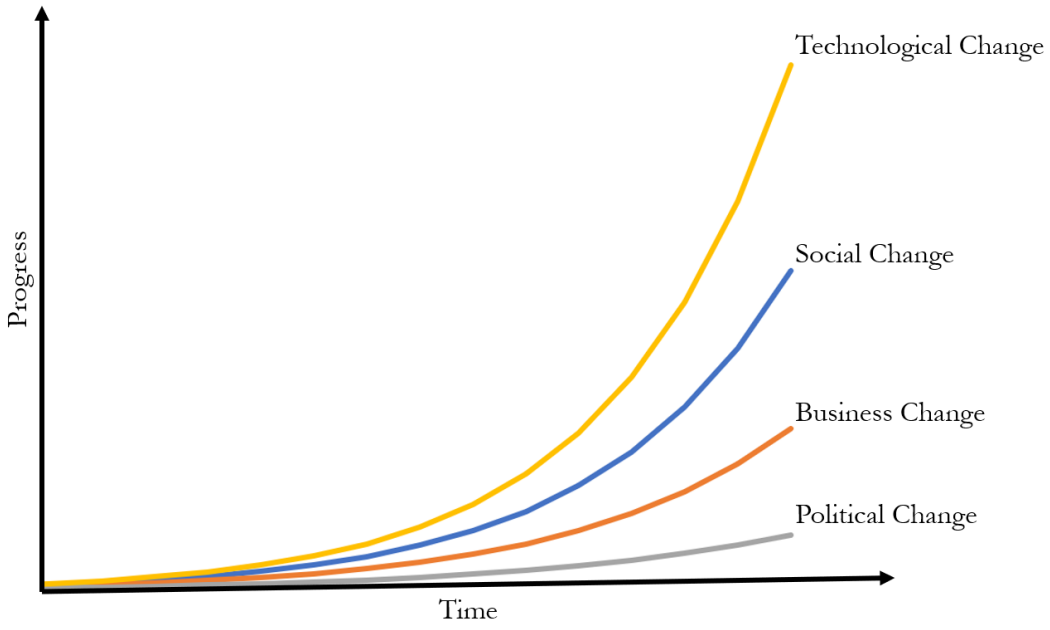


Figure 8: Law of Disruption (Downes, 2009)

In relation to SRQ5, Downes' law suggests that the business changes follow political changes, social changes follow business changes and effective disruptive technological changes occur when all the other changes are in place. The focus of this thesis is in the social and business aspects in relation to technological changes inflicted on collaborative practice. However, political factors cannot be avoided. Owen *et al.*, (2010) explains that the use of BIM has shown to have teams

replacing existing technology (2D CAD with virtual models) but not changing the processes suggesting lack of social and business change.

Driven by digitalisation namely the adoption of BIM, the evolution of roles in industry has been identified to have 5 success characteristics (Sebastian, 2011) from a case study methodology:

- Product information sharing
- Organisational roles synergy
- Work processes coordination
- Environment for teamwork
- Reference data consolidation

Azhar (2011) explains the need to lessen the learning curve for people. Systemic innovation changes the working logic of people in the industry. The literature explains the need to integrate and manage tacit knowledge to enhance performance of AEC firms (Pathirage et al., 2007).

It is acknowledged that practice cannot shift from a largely transactional to a transformational one (Smyth, 2014) without social, business and political changes (Downes, 2009)

2.3.3 Barriers to Digitalisation Exemplified by BIM

The barriers to BIM are well documented in literature, making it useful to understand the dependency on social and business origin of barriers. Figure 9 shows a summary of barriers categorised as technological, organisational and environmental (Manu et al., 2014), where organisational and environmental are more oriented with social and business changes in delivery.

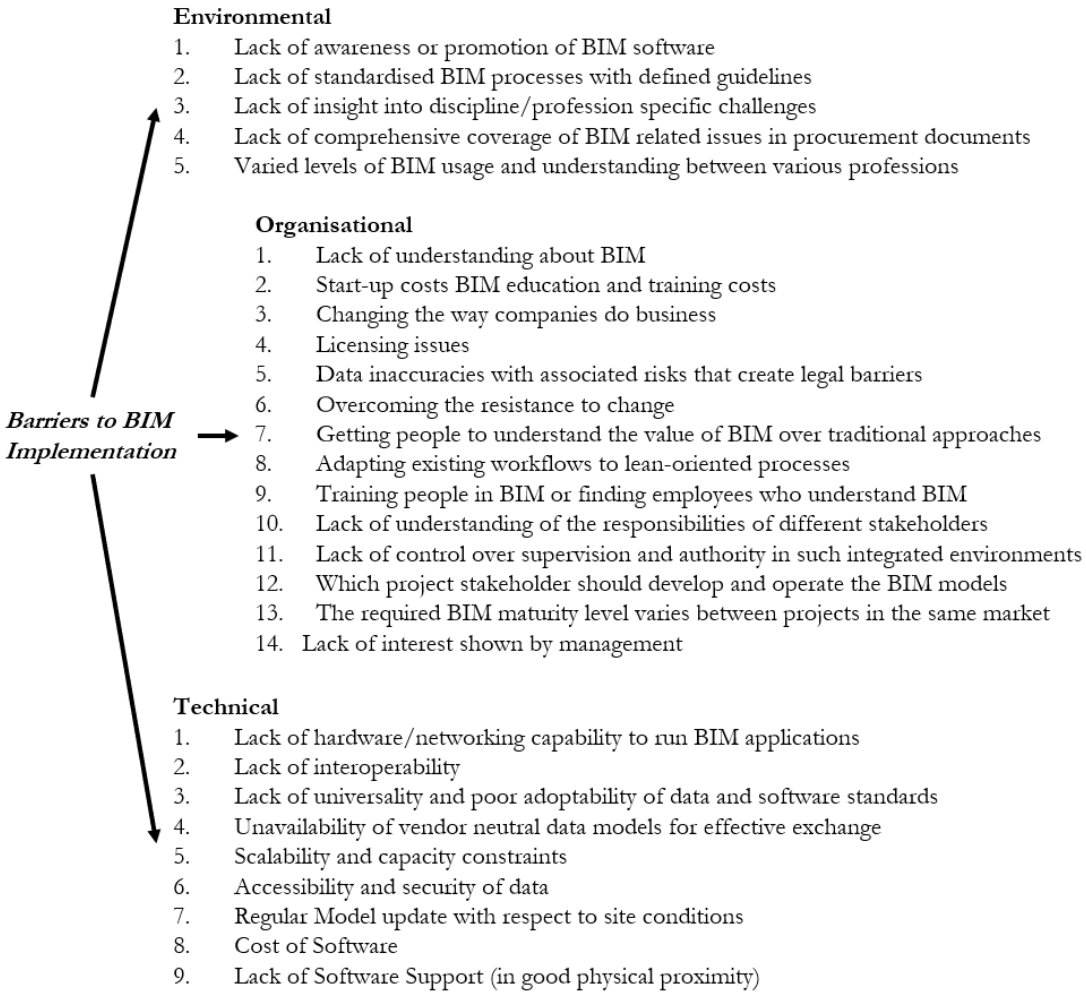


Figure 9: Barriers to BIM (Azhar, 2011; Sujan et al., 2016)

Literature also expresses the need to develop practical strategies for information exchange and integration in BIM (Matarneh and Hamed, 2017). The interface between human behaviour and technology; improved definition of transactional process models to eliminate data interoperability issues is needed (Matarneh and Hamed, 2017). This challenge can be related to the paradox of choice (Fernandez, 2017) in connection to the way software is used and procured.

Nifa & Ahmed (2014) finds that barriers as a result of the absence of contractual requirement of BIM use and the complexity of the BIM. BIM is perceived as too risky from a liability standpoint (Khosrowshahi and Arayici, 2012). Some scholars explain that the longer process in developing the Building Information Management Models (BIMM) is a barrier (Ismail et al., 2017). Although, this should be connected to a lack of knowledge in BIM as more effort is required at the design stage to avoid more costly changes at the construction phase as popularly depicted in the MacLeamy curve (MacLeamy, 2004). Other barriers included, legal issues (Bosch-Sijtsema et al., 2017), doubts on Return On Investment (ROI) (Eadie et al., 2014) and lack of demand from contractors (Gerges et al., 2017).

Papadonikolaki, van Oel & Kagioglou (2019) explains that although BIMM is typically perceived as an 'add on' technology, it affects both the structure and agency of practice. The

author expresses the importance of strategizing collaboration to enable more efficient use of digital tools. It is suggested that practitioners need to think beyond tools, go beyond formal boundaries and integrate innovative technology into project strategy to leverage the efficiency from innovation.

In summary, literature reviewed here shows barriers to BIM are more business and social oriented than technologically oriented; a motivation to focus on people. The barriers are typically observations made of practice, however, the underlying causes especially from human factors are not clear.

2.3.4 Information Latency (IL)

Information Latency (IL) is commonly used in information technology to describe the delay that information has between the stimulus and response (Murray, 2013). In this context, if it is assumed that the client is buying information about the building (product) from contractors and/or designers, this involves information transfer between the vendors themselves and the client depending on the changes made in the process which either reduces or increases latency; IL cannot be eliminated but can be reduced. Du *et al.*, (2018) categorise IL into two main classes, technical or cognitive latency. The context involving decision-making makes only the cognitive latency relevant in this case, however, the two classes cannot be separated as decisions regarding technical parts are also made which therefore affect the technical latency. Du *et al.*, (2018) define cognitive latency as the time delays between received stimulus and the subsequent response or reaction. Technical latency is the time delay in the data flow from source to its destination. The paper's findings suggest that cognitive latencies emerge from the manner in which decisions are made and can affect the technical latency of information and therefore the technical and cognitive latencies cannot be perceived to be mutually exclusive.

IL is used in analysis to explain the effect of critical factors presented on the information flow in a project from the beginning to the defined end. By utilising information latency there is unity in the approach as all factors can be related to how information flows; i.e. the more iterations that are required to generate the final version of information, the more latent the information will be as it requires to flow between participating firms more than the ideal amount.

Merschbrock & Munkvold (2015) studies the success drivers of collaborative work and found that establishing BIM change agents, cloud computing, appointing software developers, systemic learning, and the establishing new roles and responsibilities play a part in successful collaborative projects.

2.3.5 The Growing Need of Performance Metrics

Owen *et al.*, (2010) explains the lack of tools to measure quality and design integration as being a challenge in assessing the quality of integrated delivery. There is a large amount of literature surrounding the ability of BIM to increase productivity, however, much less literature on availability of metrics (Succar, 2010). The most notable of these studies into performance metrics

of BIM projects is collated and presented by (Succar et al., 2012) which follows a structure based on policy, process and technology. The policy category contains multiple constructs referring to benchmarks/controls, contracts/agreements and guidance/supervision. Whereas the process part involves, resources, activities/workflows, products/services and leadership/management. The technological aspects are outside the scope of this literature review. Similarly (Nasir et al., 2012) developed benchmarking and metrics with a central focus on time and cost of construction projects (regardless of BIM use). Although it is becoming increasingly evident that the social climate is important (Rose and Manley, 2011), there is no mention of social or psychological indicators in these studies, showing a gap in the CM domain. However, in the health care sector, these social and psychological metrics are being tested, these metrics were used in the exploratory study design and therefore presented in Section 3.2.1.

2.3.6 Summary of Digitalisation in the AEC industry

In this section, digitalisation implementation in the AEC industry and its current state are discussed using literature. Although digitalisation comes across as the focus on the tools part of IDDS, the review of literature on the barriers to the implementation of BIM shows that there is a high interdependency between all aspects of IDDS; people, process and tools.

2.4 AEC Project Delivery

Generally, relationships and interactions between people are discontinuous because of the way the industry works. This discontinuity is partly the reason that there is higher perceived risks because new relationships means higher risks; some of the main reasons the AEC industry is lagging behind others is because it involves highly transactional relationships and is resistant to change (Ey et al., 2014). Therefore, in Section 2.4.1 contracts and procurement strategies are reviewed providing a selection of the vast amount of literature that exists on the contractual barriers to information delivery (Azhar, 2011).

There is an inherent link between the procurement method and the ability of teams to use and develop innovative methods (Walker and Hampson, 2008). An important aspect is team selection and there is a large amount of literature on sub-contractor selection with reference to procurement risk, this is presented in Section 2.4.2.

From research projects of Supply Chain Management (SCM), Bankvall *et al.*, (2010) explains that the applications of SCM models from the automotive industry does not fit the AEC industry. The author explains that the automotive industry has mainly sequential interdependencies whereas the pattern is very different in the AEC industry. Therefore, lean management approaches are to be applied in the industry as described in Section 2.4.3.

Although a split is made in this chapter between client and delivery methods (contracts, procurement, etc.), it is important to note that the selection of a procurement model depends on the project nature, client's capability and the decision is the client's (Kelly, 2011; Karen and Le,

2015). Therefore, literature suggests a dependency of factors associated with project delivery on the client organisation.

2.4.1 Contracts and Procurement Strategies

A clear relationship between contract type and project performance is non-existent (Force, 1986; IPA, 2010). Rather, the alignment comes from risk perception, the contract is not a primary concern. Different contracts bring different difficulties and situations. More fundamental to project performance is the need for goal alignment requiring proper incentivization determined by the project's uncertainty of the process, complexity and uncertainty of scope (Turner and Simister, 2001).

The uncertainty of the eventual product should be used to find the appropriate type of contract (Turner and Simister, 2001) implying the dependency on the ability of client representation to express needs. Frequent changes to the forms and terms of contract and preference of price-based team selection are unfavourable to relationships between project stakeholders (Briscoe et al., 2004).

The implementation of systemic innovation changes not only the tools but also the roles of the site managers; it is predicted that site managers will take more participation in the design management process (Mäki and Kerosuo, 2015). To facilitate the effective implementation, the author also suggests the reconsideration of the contracts and timetables, partners needed for design and the division of labour between the partners.

FM is said to be seven times the initial investment costs (Lee et al., 2012) or three times the construction costs of a building (BIM Task Group, 2013). Increasing the transparency between building stakeholders during design and construction is said to enhance the FM decision-making process (Dixit et al., 2019). To bring sustainable impact to industry, considering FM is therefore important.

A large amount of literature connects contracts to project level collaboration. Contracts that are reflective of the business model are fundamental in ensuring an innovative collaborative environment (Cicmil and Marshall, 2005); the contractual effect on reducing bureaucracy, feedback of innovative ideas, identification of people to drive innovation are suggested (Asad et al., 2005). 'Soft' and 'hard' processes to avoid conflicts are suggested; common in the industry, 'hard' processes include careful planning and monitoring whereas 'soft' processes include efforts to foster motivation (Larsson et al., 2018).

Contractual rules are suggested to bring out relative behaviours and strategies bounded by behavioural beliefs (Kadefors, 2004). The nature of the AEC business model and contracts is suggested to constitute polarised service providers (Dulaimi et al., 2002). This generates major obstacles in enforcing common values, goals and orientation needed to achieve harmony and cooperation (Bresnen and Marshall, 2000a). The implementation of new procurement methods brought about by partnering (Bresnen and Marshall, 2000a) and adapted project inter-

organisational structures called clusters (Nicolini et al., 2001) are suggested to improve the nature of integrated and innovative solutions. With regards to project level collaboration, partnering can be perceived as sharing the risks and rewards, removing the individualistic nature of contracts. Relationship management in the form of alliancing and partnering is suggested (Blayse and Manley, 2004). Relational contracting is an overarching theme used to describe partnering, alliancing, joint venturing and any other collaborative arrangement which has similarity in the shared risk and reward (Cheung and Rowlingson, 2005). On contracts with shared risks and rewards, the risk of liability is significantly reduced and therefore facilitates the openness in sharing information (Glick and Guggemos, 2009). Whereas, clustering reduces the established divisions of labour and practices (Nicolini et al., 2001) making the solution delivery more lean in principle. Partnering practices are found to have potential in positively influencing trust and creative teamwork (Kadefors, 2004).

Regarding integration of the business model and contracts, early contractor involvement has been related to improved design outputs resulting in optimized schedule time (Song et al., 2009). Failure of project inter-team integration in early phases can result in later planning problems, delays and disputes (Arditi et al., 2002), also resulting in late projects and litigation (El Asmar et al., 2009). The lack of integration results in teams putting effort in contractual deliverables rather than defining the best solutions for the project (Forgues and Koskela, 2009). The adversarial roles are suggested to be as a result of traditional contracts which are individualistic resulting in avoidable disputes (Hauck 2004). Close monitoring of contractors is a sign of distrust, found to induce opportunism and negatively impact collaboration (Kadefors, 2004).

The selection of teams is also an important part of the procurement process where price-based selection are still dominant (Loosemore and Richard, 2015). Even though, existing relationships between teams are shown to add value to the project (further explained in Section 2.6.7), it is rarely used in team selection (Buvik and Rolfsen, 2015).

Business ethics is associated with the roles of teams in industry and has opened a new stream of literature. The growing demand of good ethical practice and professional behaviour is industry driven (Vee and Skitmore, 2003). This suggests implications in the way that teams are procured relating to trust.

One of the partnering contractual schemes is IPD, defined as:

> *'a project delivery approach that integrates people, systems, business structures into practices into a process that collaboratively harness the talents and insights of all project participants to optimise project results, increase value to the owner, reduces waste and maximise efficiency though all phases of design, fabrication and construction' (AIA, 2007)*

IPD and Alliance help resolve these difficulties by ensuring earlier involvement and a more positive collaborative environment driven by increased trust between stakeholders facilitated by

shared risks and rewards (Pishdad-Bozorgi and Beliveau, 2016). IPD helps develop system based, contextual and cognition based trust (Pishdad-Bozorgi and Beliveau, 2016), however, the affect based (emotional) trust is not developed because of the transient nature of the industry. It has shown improvements in quality, schedule, project changes, environmental and financial performance (El Asmar et al., 2013).

A contract clause explaining the requirement of no blame is suggested (Lloyd-Walker et al., 2014) although this is debateable as the contract is suggested as being subjective.

2.4.2 Team (Sub-Contractor) Selection

A large amount of literature exists with the selection criteria of sub-contractors bringing a valid holistic perspective of the academic understanding and prioritization of factors. A review of literature in contractor selection process was conducted covering five databases with journal papers from 1991 to 2015 (Araújo et al., 2018). Generally, from 2006, there has been almost double the number of publications on the topic, which is increasing every year. The selection criteria of projects vary depending on the type of projects. Financial criteria for selection was found in all the projects studied. Only 4 papers out of the 64 studied reported risk as a category for selection. The criteria found according to literature with an indicator of number of citations (low <40, Medium > 40 and <80, High >80; Bid process (low):

- Company management (Medium),
- Experience (Medium),
- Financial (High),
- Flexibility and responsiveness (Low),
- Health and safety / environment (Medium),
- Location (Low),
- Maintenance (Low),
- Market (Low),
- Procurement process (Low),
- Quality (High),
- Relationship with stakeholders (Medium),
- Reputation / Image (Low),
- Resources (Low),
- Risk (Low),
- Site capacity / facilities (Low),
- Staff features (High),
- Supplier performance (Low),
- Technical / technology (Low),
- Time (Medium),
- Transport (delivery and storage) (Low).

The criteria that were highly cited was financial, quality, staff features which are also consistent with the owners' focus (Holt et al., 1994). This shows dependency between team selection and the client/owner's perspective of the process.

Deep, Gajendran & Jefferies (2019) conducted a literature review of 110 articles after analysing the content of 800 articles, the author's focus was in collaboration between sub-contractors. The author finds the following collaboration constraints (see Figure 10) under seven procurement risks. The author's development of a mathematical representation of collaboration is evident of the positivistic nature of the domain. In essence, the message portrayed is that the collaboration between contractor and sub-contractor is as a result of trust, commitment in

achieving common goal and reliability of project participants. Figure 10 shows a summary of procurement risks, collaboration inhibitors/enablers from the author's review.

Procurement risk	Collaboration constraints	Researchers supporting the idea	Total citations	Potential collaboration enablers
Unfair risk allocation	Opportunism	145	419	Trust, commitment, Reliability, market conditions and nature of relationship
	Regionalism	113		
	Arm's length relationship	127		
	Profit margins	34		
The commitment of parties to a contract	Arm's length relationship	125	383	Trust, reliability, market conditions, nature of relationship, and behaviour
	Communication failures	56		
	Breach of trust	78		
	Profit margins	28		
	Opportunism	96		
Reliability of subcontractor/supplier	Arm's length relationship	145	362	Trust, commitment, market conditions and nature of relationship
	Communication failures	80		
	Breach of trust	100		
	Regionalism	37		
Offshore procurement risks	Communication failure	79	345	Trust, reliability and Market Conditions
	Opportunism	112		
	Force majeure	17		
	Socio-political scenario	10		
Financial risk	Breach of trust	127	230	Commitment and reliability
	Communication failures	52		
	Profit margins	24		
	Opportunism	80		
	Competence	74		
Logistical risks	Opportunism	32	214	Trust, commitment and reliability Market conditions, nature of relationship and behaviour
	Breach of trust	18		
	Regionalism	52		
	Force majeure	100		
	Socio-political scenario	12		
Inventory risks	Arm's length relationship	85	156	Trust, commitment, reliability, market conditions and nature of relationship
	Communication failure	16		
	Competence	12		
	Project complexity	43		

Figure 10: Procurement Risks, Collaboration Constraints and Enablers Found in Literature Review by Deep, Gajendran & Jefferies (2019) (Figure used with the permission of author)

Procurement risks are valid in studying collaboration as risks from the procurement process can impact the reality of constraints and enablers of collaboration applied (Tanko et al., 2017; Kapogiannis and Sherratt, 2018; Koolwijk et al., 2018; Yazdani et al., 2019; Zhang et al., 2019).

Breach of trust was found to be a significant constraint related to five of seven procurement risks. The seven procurement risks are briefly described in Sections 2.4.2.1 to 2.4.2.7.

2.4.2.1 Unfair Risk Allocation

Sub-contractors may be exposed to high risk and uncertainty due to risks being passed along through the procurement chain (Donato, 2016; Mathivathanan et al., 2018). The client's selection of a procurement method is influenced by many variables which inflicts allocation of responsibilities and liability amongst the firms which brings different levels of collaboration and differential risk/reward profiles to each firm (Love et al., 2015; Love, Irani, et al., 2017; Perez et al., 2017).

2.4.2.2 Commitment of Parties to a Contract

Commitment of a firm to a contract begins with the commitment of senior management of each construction organisation in a project (CII, 1991). Jelodar, Yiu & Wilkinson (2016) explains the differential perspectives when teams collaborate making it essential that they show commitment. Zhang *et al.*, (2019) explains that to avoid conflict and breaches of trust, there is need for a combination of higher and lower organisational commitment.

To improve commitment, developing mutual goals (Babaeian Jelodar et al., 2016; Jelodar et al., 2016), keeping long-term relationships and integrating sub-contractors and suppliers into the supply chain are said to improve profit margin and performance (Forsythe, 2016).

2.4.2.3 Supplier Reliability

The low supplier reliability is partly attributed to arm's length relationships, communication failures, breaches in trust and regionalism (Ercan, 2019; Meng, 2019). Often, conflicting goals between contractor and sub-contractors exist as one party questions the gainful modifications proposed by the other firm (Hartmann and Caerteling, 2010). The lack of openness of finance from sub-contractors and the absence of trust brings reduced profit margins to the main contractors (Hartmann and Caerteling, 2010; Ling et al., 2014).

2.4.2.4 Offshore Procurement Risks

These risks are attributed to the globally serviced parts of the supply chain. The risks are alleviated by non-controllable aspects such as socio-political unrests which can delay or increase the price of products/service (Sundquist et al., 2018; Olawumi and Chan, 2019; Ortiz et al., 2019). Evidence suggests that these offshore collaborations are based on trust, failure leads to loss of collaboration (Pal et al., 2017). For these relationships, efficient communication is crucial amongst project participants (Love, Zhou, et al., 2017).

2.4.2.5 Financial Risks

Financial risks are globally a significant part of project performance (Love, Irani, et al., 2017). Financial risks are suggested to be as a result of socio-political issues, unreliable estimates and

underestimation of the impact of cost overrun (Terrill and Danks, 2016). These financial risks result in claims and counterclaims which need to be transacted between teams and therefore result in delays in payment putting more risk in breaching trust and relationships.

2.4.2.6 Logistical Risks

Logistical costs of a project are a significant part of the total project cost (Sundquist et al., 2018). Bankvall *et al.*, (2010) contemplates whether the complexity of construction is threatening performance as compared to other sectors due to the interdependencies between activities and the fragmented stakeholders.

2.4.2.7 Inventory Risks

Inventory in a construction project is the raw materials or finished products that are stored on or off site (Thunberg and Persson, 2014). These risks are asymptomatic of the underlying challenges in lack of competencies, arm's length relationships, communication failures and complexity (Lin et al., 2018; K.V. et al., 2019; Ortiz et al., 2019).

2.4.3 Lean Management Approaches

Lean practices constitute waste reduction in both tangible and intangible forms (Erik Eriksson, 2010). In this context the intangible forms are the primary focus e.g., waste reduction in information transfer and technology (Green and May, 2005). Lean is predominantly thought of as production control (Ballard and Howell, 1997; Choo et al., 1999; Ballard, 2000) even though the Egan report generalises the terminology to effective techniques used to eliminate waste (Egan, 1998). Generally, a vagueness of definition, contradictions and ambiguities in the use of lean terminology are found in literature (Green and May, 2005).

(Green and May, 2005) conducted twenty-five interviews with individuals working in policy making organisations centred on lean management. Based on their understanding the author develops three models:

- Waste elimination – ensuring a smooth, uninterrupted flow of activities
- Partnering – lean is seen as an outcome of better relationships
- Structuring the context – fundamental changes in the industry to facilitate long-term relationships and integrated teams

From the above mental models, it is evident that lean philosophy involves collaboration and the human element in developing relationships and changing the industry to suit digitalisation. Green & May (2005) acknowledges that changes in working methods that incorporate lean practices undergo complex processes of social shaping which allow diffusion across inter-organisational barriers. The definition of lean is socially constructed depending on the local application of the phenomena.

2.4.4 Summary of AEC Project Delivery

The way project are delivered depend on the way teams are procured, selected and managed. The primary focus is in the process and people part of the IDDS framework. The influence from these on collaboration, the use of tools and information exchange is critical as these aspects can be related to the motivation of teams (see Section 2.6.6). From literature it is suggested that shared risks and reward and integrating project delivery have a positive effect on collaborative practice.

2.5 The Role and Value of a Construction Client

The client is found to be the most influential stakeholder in the development of a social enterprise to ensure a robust project management and policies, external project factors, project policies and project leadership (Rodríguez-Segura et al., 2016; Loosemore, 2016). The client is involved in selecting the way a project is procured, making supply chain integration challenging without the support and understanding of the client (Briscoe et al., 2004). This role is crucial as clients intervene at development and implementation stages of the design and construction process (Thompson, 1991). There are a number of external and internal influences on the client such as that stemming from departmental and organisational structures, experiences of individuals and business markets (Briscoe et al., 2004).

In Project Based Inter-Organisational Networks (PBIONs), success is subjective, the client/end-user and the company developing the project need to define project success. The client is suggested to promote collaboration as part of their criteria for successful projects and not solely the financial aspects (Karen and Le, 2015; Pesämaa et al., 2018). Furthermore, the client needs to believe in the benefits of choosing teams not solely on price but also based on the possibility to have positive collaboration and professional skills (De Araújo et al., 2017).

The Egan report explains the need for clients to be encouraged to get involved (Egan, 2002; Loosemore and Richard, 2015). The nature of the client's involvement is significant (Assaf et al., 2018) and the lack of client knowledge and experience was found as a result of the inability to communicate their needs efficiently and understand deliverables (Loosemore and Richard, 2015). The client requires to clearly understand their own business needs to allow the possibility of achieving integrated teams at an early stage of a project (Briscoe et al., 2004).

Client trust towards project teams is required and exemplified by the use of contracts (Che Ibrahim et al., 2015). Kadefors (2004) explains that clients feel vulnerable when relating to contractors and therefore, stricter, less flexible traditional contracts are misperceived as less risky compared to contracts that alleviate collaboration. The vulnerability of the client is partly from potential negative impacts of opportunism as a result of unavoidable contract gaps and missing provisions (Boukendour, 2007). Examples of scenarios of projects in which clients control contracts and procurement results in the drivers of the overcontrolling attitude being the common belief that the building industry is all about making money out of the client described as opportunism (Van-Duren and Voordijk, 2015).

Literature signifies the effect of client risks on project consultants, however, this is not as common in relation to the risks posed by consultants or contractors (Kometa et al., 1996). The client's behaviour is related to the financial aspects of the project which affects the project level; a more consulting attitude rather than an enforcing attitude is required by project teams (Kometa et al., 1996). Furthermore, continuity of client workload promotes commitment and collaboration (Briscoe et al., 2004). In relation to innovative processes, the client is to understand the need for early investment in processes (Pesämaa et al., 2018)

Preece *et al.*, (2015) reviewed Customer Relationship Management (CRM) benefits and challenges in construction organisations. The study shows the limited research efforts of CRM in the CM domain. The benefits of CRM are primarily centred around improving the relationship with existing clients enabling increased possibility retain customers signifying that the nature of a client's relationship with teams can reap rewards.

In summary, the role and value of the client to the development of innovation and collaborative practice is foundationally significant as they have influence on all aspects of the IDDS model. The foundational dependence on the client is due to their strong influence on project decisions.

2.6 The Psychological and Social Aspects of Collaboration

Concepts drawn from psychology and sociology; approaches to connect reality to theory and Construction Management (CM) domain specific factors are contained within this section.

Volker (2019) calls for studies in actual management practice to better understand the drivers of actors in the existing social and cultural systems, claiming there is need to obtain inspiration from other fields. The author presented multiple reasons to show that the CM practice has suitable conditions for valuable scientific contributions, represented as:

- Ease of access to study participants
- Interesting study participants resulting from the complexity of construction projects
- Industry is a grateful audience
- Considerable social and theoretical relevance

Furthermore, the CM domain should stimulate reflection and critique to increase research impact rather than trying to find solutions (Volker, 2019). Therefore, making it important to understand the way decisions are made (as described in Section 2.6.1), in order to understand the focus of theoretical transfer from psychology to CM.

A critical understanding of social theory (see Section 2.6.2) from literature, to develop strategies of understanding complex data reflecting social reality is needed to develop the researcher's sense-making process and played a role in the development of the researcher's analytical approach.

Ruppert-Winkel *et al.*, (2015) explain the need for a connection between society and nature; Transdisciplinary Sustainability Science (TSS) provides a multi-disciplinary approach to

solving real-world problems consisting of both scientific and non-scientific knowledge. TSS's high complexity in communication and coordination of the areas studied requires significant simplification to draw findings; thinking of reality as a combination of interacting systems is therefore valid. This way of thinking, to combine knowledge from multiple domains using systems thinking is described and explained in Section 2.6.3.

There are key elements pertaining to human factors which are relevant. First, the motivation to manage the cultural aspects of construction projects can be used to reduce the risk of dissatisfaction by reducing the risk of behavioural aspects (Tijhuis, 2011: p. 2). Culture is defined as 'the collective programming of the human mind which makes one human group different from another' (Hofstede, Hofstede & Minkov, 2010: p. 6). Section 2.6.3 reviews CM literature using organisations as a group.

In addition, psychological comfort (or discomfort) are phenomena that emerged in the data collected in this research in connection with changes in processes brought from implementation of systemic innovation; a general understanding from psychology literature is outlined in Section 2.6.5.

CM domain trends regarding individual extrinsic and intrinsic motivation are described in Section 2.6.6. Furthermore, more specifically to the CM domain, the way trust between teams develops and affects a project is described in Section 2.6.7.

2.6.1 Decision-making

The evolution of the theoretical understanding of an individual's process of decision-making has evolved to consider irrationality using a concept called heuristics (see Section 2.6.1.1) which partly draws on one's beliefs and experiences (see Section 2.6.1.1). There is still debate about the degree of rationality of decision makers. It is fair to conclude that rational theories assume that every decision maker knows all the alternative actions and is able to estimate probability of the consequences of those actions (March, 1991). An overview of the theories is discussed in this section.

Probability theory (Bayes, 1991 first presented in 1763) and utility theory (Bernoulli, 1954 first presented in 1738) presented models on how individuals should make decisions. The expected utility theory (Morgenstern and Von Neumann, 1953) is considered as one of the first prescriptive decision theories for its conditions for model applicability. The models assumed that decisions are made rationally. More recent empirical evidence suggests that decision behaviour is not always within the realms defined by utility and probability theory (Beach and Connolly, 2005); real life decisions cannot be treated like gambling, irrational factors are present (Volker, 2019).

The ability of decision makers is bounded (Simon, 1987); giving way to a new angle in behavioural decision theories. This new angle (i.e., bounded rationality) involved finding ways that choice deviates from the bounded rational information; the concept of rules of thumb described as 'heuristics' was introduced by (Tversky and Kahneman, 1974). Heuristics reduces

the time and effort required to make decisions especially in repetitive or stressful circumstances (Cyert and March, 1963).

Despite the development of behavioural decision theory, there have not been significant contribution to organisational applications (Hodgkinson and Starbuck, 2008). Problems from real life circumstances are specific to the organisation type and involve multiple scientific disciplines (Kieser and Wellstein, 2008). Another generation of behavioural decision theory is called naturalistic research and theory which describes how decisions are made in a more realistic way (Beach and Connolly, 2005); such as, intuition, mood, emotion, and affect, which became more prominent.

Decision-making in organisations is strongly influenced by structure and norms of the organisation meaning that decision makers use a subset of options that are available (Simon, 2013). With the aims of going beyond rationality, researchers started to explore processes within organisations that are irrational, focusing on the way people use their experiences to make decisions (Lipshitz et al., 2006). Four stages to decision-making are acknowledged as information acquisition, evaluation, action and feedback/learning (Demski and Swieringa, 1981). These stages are iterative, interactions between the stages are often what create value.

From the CM domain, increasing complexity of construction projects comes from growing demands of stakeholders and proliferating multidisciplinary supply chains mobilised to deliver the project (Kumaraswamy et al., 2004; Craig and Sommerville, 2006); the decision criteria of many stakeholders is increasing in numbers and complexity.

The diverse or divergent intra or inter-organisational objectives result in complex scenarios. Critical decisions are needed in procurement strategies in the beginning of a project, followed by critical design decisions, selection of contractors and service providers (Kumaraswamy et al., 2004). Accurate and timely decisions are required at various stages of construction projects.

Kumaraswamy *et al.*, (2004) presented the decision support needs of large clients who have multiple projects. The author's suggestion for further research, applicable to this thesis are:

- Addressing persistent ontological problems in different construction domains – understanding of the nature of reality in practice,
- Establishing acceptable rules of engagement including trust issues amongst collaborators,
- Understanding the constituents of trusting relationships,
- Understanding interaction and communication between collaborators.

With respect to these suggestions, firstly, understanding of the process of individual decision-making is necessary using heuristics and possible biases (see Section 2.6.1.1). Secondly, decision-making is also social in nature, therefore the theory of behaviour was used to understand the way beliefs influence decisions (see Section 2.6.1.2).

2.6.1.1 Heuristics and Bias in Decision-making

Heuristics are mental shortcuts people use based on little information that reduces the cognitive burden associated with decision-making (Shah and Oppenheimer, 2008). It is possible therefore that mental shortcuts could introduce biased assumptions that decisions are made with (Dietrich, 2010). Montibeller & Winterfeldt (2015) conducted a review on cognitive and motivational biases in decision-making which result in Psychophysical Based (PB) and Association Based (AB) errors. PB errors result from bias relating to incorrect mappings of reality and psychological responses. AB errors result from an automatic mental association with past experience. Both AB and PB are said to be difficult to correct (Montibeller and Winterfeldt, 2015).

Equivocality is defined as the human problem of managing multiple meanings and conflicting interpretations (Weick, 1979). Equivocality results in uncertainty of perception of information resulting in the need to use heuristics (Daft and Weick, 1984). There is a whole range of studies e.g., Rachel Dinur (2011); Neill & Rose (2007); Levander *et al.* (2011) study the way heuristics is used in making decisions in equivocal situations. Equivocality and uncertainty are both common in client firms and the decision-making systems adopted leaving little room for improvement in their information processing practice (Levander et al., 2011).

Although it is important to have a basic understanding of how decisions are made, in this context, the primary focus is not in the way people process decisions but is in understanding the inter-team centred influence on decisions that lead to biases. Biases have been studied and documented in detail by authors such as Tversky & Kahneman (1974) and Gilovich, Griffin & Kahneman (2002). Cognitive biases are systematic discrepancies between the 'optimal' answer in a judgemental task and the decision makers actual answer. The difference is said to be caused by a normative rule (Von Winterfeldt, D. and Edwards, 1986) i.e. the way a task is usually or should be done. Motivational biases are those that judgements are influenced by (un)desirability of outcome/choices (Von Winterfeldt, D. and Edwards, 1986).

Kometa, Olomolaiye & Harris (1996) explain the contextual importance of understanding the biases that affect decision-making and that biases indeed exist. They explain how these biases can come from both internal and external factors. Internal factors include the decision maker's attitude towards risk, organisational structure, experience, and resource availability. Whereas, external factors are, for example, governmental regulations and current market conditions. By focusing on the way people are bias in decision-making, contributions from multiple unclear cause and effect relationships can be studied to infer better understanding of a complex problem. Table 2 shows the definitions of common cognitive and motivation biases used for theoretical application in the research.

Table 2: Decision Making Biases as Defined in Psychology Literature (Adapted from Montibeller & Winterfeldt, 2015)

Type of Bias	Name of Bias	Definition
Psychophysically Based Cognitive Bias	Gain-loss bias	When a decision is made based on a positive or negative connotation, brought about by lack of certainty in information to show whether the decision would result in a positive/negative attribute to the cause (Amos and Daniel, 1981; Levin et al., 1998)
	Anchoring bias	Occurs when the estimation of a numerical value is based on an initial value, then adjusted insufficiently to provide the final answer (Tversky and Kahneman, 1974)
	Certainty bias	The preference of events or outcomes that have a higher probability of being true (Kahneman and Tversky, 2013)
	Equalising bias	When decision makers allocate similar weights to objectives, probabilities or events (Fox and Clemen, 2005; Fox et al., 2007; Jacobi and Hobbs, 2007)
Association Based Motivational Biases	Confirmation bias	Occurs when there is a desire to confirm one's belief which usually occurs as unconscious selectivity in how evidence is used (Nickerson, 1998)
	Affect influenced bias	Occurs when there is a positive or negative emotional predisposition for a specific outcome or option (Finucane et al., 2000; Slovic et al., 2012)
	'Desirability' bias	Occurs when there is 'wishful' thinking, the desirable outcome is favoured to make a decision (Krizan and Windschitl, 2007)
	'Undesirability' bias	Occurs when there is a desire to be cautious or conservatives in estimates that can lead to harm (Dolinski et al., 1987)
Association Based Cognitive Biases	Overconfidence bias	Occurs when decision makers provide estimates for a given parameter that are overestimated or too precise (Lichtenstein and Fischhoff, 1977; Moore and Healy, 2008)
	Omission of important variable bias	Occurs when an important variable is overlooked (Jargowsky, 2005)
	Myopic problem representation bias	When an oversimplified problem representation is adopted which is based on an incomplete mental model (Legrenzi et al., 1993; Legrenzi and Girotto, 1996; Payne et al., 1999)
	Tangibility Bias	Occurs when there is 'the tendency to favour what we can see and understand over what we cannot' (Thiele et al., 2011, p. 284)
	Availability bias	Occurs when the probability of an event is easily recalled or overstated (Tversky and Kahneman, 1973; Bazerman, 1994)

2.6.1.2 Theory of Planned Behaviour: The Role of Beliefs

The importance of beliefs in decision-making is famously made evident by the Müller-Lyer illusion (Figure 11); making a challenging concept easily relatable. Without prior knowledge, the two lines are easily misperceived for not being the same length; however, when one has the knowledge that they are, the two lines appear to be the same length. This is an example of the way that a change in belief can impact individual human perception (Kahneman, 2012).

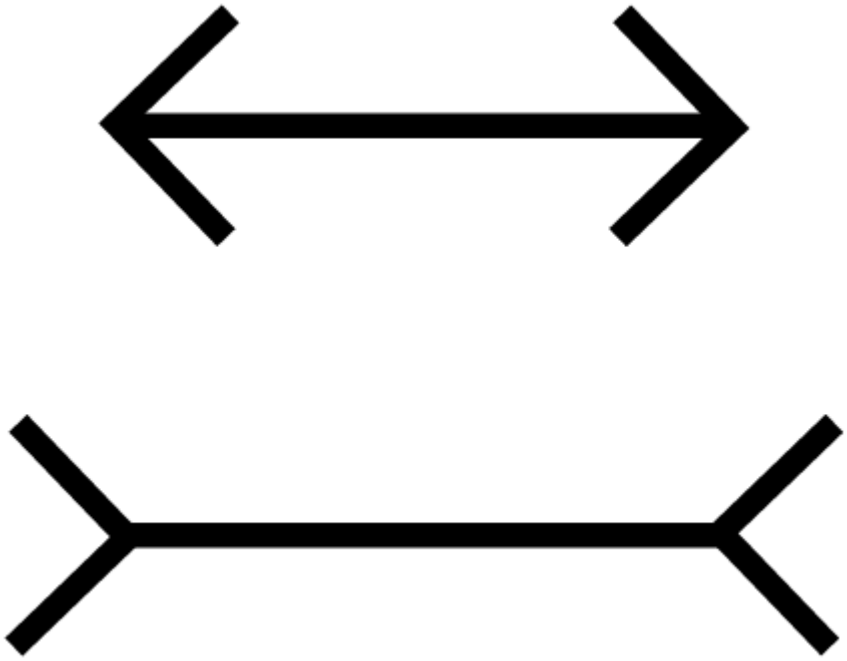


Figure 11: Müller-Lyer Illusion (Redrawn from Kahneman, 2012)

> *'Decision-making is essentially social behaviour even when there is nobody else present, because one anticipates how others will react and factors this into this decision' (Beach & Connolly, 2005: p. 23)*

Many decisions are not made alone but in groups, therefore, people align their individual decision-making process by sharing beliefs and values (Beach and Connolly, 2005). If values and beliefs are the same, people are more likely to understand one another (Volker, 2019). This also reinforces that similarity in values and beliefs make them more resistant to change. The Theory of Planned Behaviour (TPB) is therefore suitable for connecting human actions and beliefs.

Ajzen (1985) presents the TPB; understanding how the behaviour of people can be changed. This means that the behaviour of people is in theory, controllable and understandable, forming the motivation and assumptions of theoretical application in this research. The preceding theory was called the Theory of Reasoned Action which explains that behaviour is not completely voluntary nor under control. TPB took this forward by claiming that there is a perceived

behavioural control, which means that some aspects are voluntary, and others are controlled. TPB brings about three constructs that affect human actions:

(1) Behavioural beliefs – beliefs about the consequence of actions,

(2) Normative beliefs – beliefs of what is normal to others,

(3) Control beliefs – beliefs of factors that affect behaviour.

Ajzen (2002) investigated the effects of past experiences on later behaviour and found evidence of its effect; past experiences impact behaviour if measures of intention and behaviour of others are compatible. Additionally, the impact of past experience vanishes with strong, well planned intentions and realistic expectations.

Pishdad-Bozorgi and Beliveau (2016) found that commitment to an IPD project requires trust in other teams and the procurement system itself which requires experience in similar situations; developed behavioural beliefs regarding the way the procurement strategy responds to dispute causing scenarios. Expectations about the constitution of appropriate behaviour are not only judged by technical and economical rationality but are also shaped by external factors (Heugens and Lander, 2009). Consequently, organisations operating in the same field tend to adopt similar structures and practices owing to the forces exerted on them by governments, associations customers, and so on (DiMaggio and Powell, 1983). Additionally, the societal factors that affect cognition and behaviour of actors are professions, corporations, family and religions (Thornton et al., 2012).

2.6.2 Social Theory

Two complementary theories are described in this section; Structuration theory (see Section 2.6.2.1) provides the basic understanding of sociological principles requiring a contextual theory to accompany it. Cultural Historical Activity Theory (CHAT), described in Section 2.6.2.2, is applied by scholars to describe the AEC industry by combining historical changes and cultural aspects.

2.6.2.1 Structuration Theory

From a sociologist's point of view, procurement of work can be looked at as the creation of social groups using structure and agency. According to Giddens (1986), change is happening naturally but can also be accelerated. In order to assess what can accelerate change, Giddens defined agents as the individuals responsible for change who are controlled by the social structure of their network such as traditions, moral codes or established ways of working and doing things.

Structuration theory presented by Giddens (1984) focuses on the interaction between agents and structure; this enables the idealisation of this process; as an iterative one where repeated changes made by individual agents affect organisational structure.

For structuration to apply the micro level activity needs to be coupled with the macro level activity; what is changed (through agency) must be with respect to the existing conditions (defined by structure).

Practices within the AEC industry stipulate a decentralised way of working where no independent member of the inter-organisational group is an agent, assuming that one change by an agent affects every network member depending on their perspective. It can be argued therefore that should various changes by different independent agents be made, these can give way to an overall complex change which can affect the social structure in a way that is difficult to comprehend.

Broger (2011) explains how structuration theory's integrative perspective is valuable although it is not seen that way by many researchers as they may fail to see the explanatory potential of the theory. He also claimed that there is a need for a philosophical companion to structuration theory, for example, CHAT.

2.6.2.2 Cultural Historical Activity Theory (CHAT)

The AEC industry is getting increasingly complex with more construction stakeholders are looking to engage in integrated and collaborative ways of project delivery (Evbuomwan and Anumba, 1998). CHAT provides a theory that deals with complex interacting activity systems that are contradictory by nature and where the knowledge and learning are distributed across the elements of the system (Engeström, 1987). CHAT gives importance to activities organised around the use of tools. Therefore, in this context, the introduction of BIMM tools affected elements of the system in various ways. CHAT gives priority to why networks are functioning in a certain way rather than in other ways in this context. CHAT explains that any system is developing historically and only through analysis of historical development of practices it is possible to trace the systemic contradictions that impact slow diffusion of innovations (Engeström, 1987).

From the CHAT perspective, the higher the level of fragmentation, the higher the number of interacting activity systems, more tensions and conflicts are manifested in practices. Putham (1986) states that identification of systemic contradictions can help to decipher underlying roots of problems in fragmented and ever-changing organisations as organisations do not develop on their own; people create organisations.

2.6.3 Systems Thinking

Vandenbroeck *et al.*, (2014) explains that systems thinking focuses on developing models for intervention in real-world problems utilising information gathered from the people involved in the process; a socio-technical holistic perspective. The reasons for using holistic approaches:

- A different approach to reductionist science where complex interactions are simplified to the sum of constituent parts. The method allows the use of parameters from different domains of knowledge, e.g., the complex social aspects are inter-linked with the technical and business aspects in this thesis. As people are the centre of these links, utilising their perceptions based on experiences can provide insight (Vandenbroeck et al., 2014).
- Developing solutions based on feedback rather than existing theory and intuition. Researchers accept that reality is more complicated than can be perceived (Vandenbroeck et al., 2014).

- Unlike phenomenon found in natural sciences where the effect is studied based on a cause, the approach is the reverse; the study of the effect to theorise causes (Vandenbroeck et al., 2014).
- Theories/simplification cannot help in understanding problems, as there is mutual interdependence between the components in a system creating a problematic situation; relationships between components/theories are unknown (Vandenbroeck et al., 2014).
- Methods retrieving information from actors affected by the difficulty can help us understand their social and technical nature (Vandenbroeck et al., 2014).
- Only a partial picture of reality can be derived with reductionist/conventional science (Checkland, 2000).
- Allows dialogue between different views of the problematic situation (Checkland, 2000).
- Technical complexity is linked explicitly to social complexity (Vandenbroeck et al., 2014).
- Academics claim that complexity science utilising a holistic view can explain 'a lot from a little' (Phelan, 2001).

2.6.4 Organisational Culture

Research in organisational culture was initially applied in CM by practitioners awakening researchers to the subject (Nukic and Huemann, 2016). There are multiple definitions of the phenomenon but the more widely accepted sits at deeper levels of assumptions and beliefs that are shared by members of an organisation which, in turn, define their view of the external environment (Schein, 1985). Another view is the way that norms for behaviours in an organisation affect individuals' understanding of the organisation's functions (Deshpande and Webster Jr, 1989).

It is implied that team cohesiveness and performance demand the recognition of collaboration, suggesting that team leaders have both a professional role but also one for human concern for subordinates and co-workers (Nukic and Huemann, 2016).

Individual decision-making is connected to the organisational hierarchy although it is far more complex than just the organisational structure (Barnard and Simon, 1947); influence is also attributed to the authority, identification, criterion of efficiency, advice, information and training. Indeed, organisational hierarchy affects the way decisions are made to solve problems and develop process (Schneeweiβ, 1995).

Several characteristics of AEC firms are different from other industries; poorly shared perceptions, lack of communication between occupational levels, higher fragmentation and hierarchy (from subcontracting), companies have at least two identities (head office team vs site office team), cultural differences between the main stakeholders (Riley and Clare-Brown, 2001).

Cultural differences between design and construction organisations are found to be common in multiple global industries (Nukic and Huemann, 2016). In relation to performance

and cultures, evidence suggests that the interaction is shaped by the national culture (Denison et al., 2004).

Partnering cultures could improve project performance despite cultural differences (Phua and Rowlinson, 2004; Zhang and Liu, 2006). Additionally, this should be done by promoting similarities in organisational cultures amongst the partnering organisations (Nifa and Ahmed, 2014).

In summary; organisational culture brings a complexity of collective values and beliefs that influence behaviour of their employees, national differences in culture exist, behaviour differences arise from both organisation and individual characteristics, it is possible to assess organisational culture (Nukic and Huemann, 2016). For this research, the project perspective is adopted where individual organisational culture is also considered as significant. Furthermore, from a study of the culture in the Croatian AEC industry, a clan culture is common determined by loyalty, tradition, and collaboration between specific groups of companies. Furthermore, public companies tend to be have a more hierarchical type of organisational culture compared to private firms (Nukic and Huemann, 2016).

Organisational culture in joint venture partnerships have been found to affect the performance of the joint venture where it is suggested that national culture has less significance than organisational culture (Ozorhon et al., 2008).

In the scheme of the thesis, and due to the multiple definitions of organisational culture, it is important to explain that organisational culture contained in this thesis is framed for factors within independent organisations.

2.6.5 Psychological (Dis)Comfort

Comfort is a basic aspect of life. It can be perceived to be related to both tangible and intangible artefacts. The application of comfort in this thesis is that of a psychological one. (Pineau, 1982) found that, comfort is not purely material; it has psychological aspects in relation to e.g.:

- Personalisation: making something one's own e.g., doing a process one is familiar with, therefore able to customise
- Freedom of choice: the ability to distance one's decision-making from others
- Space: an artefact that drives the freedom of choice and personalisation
- Warmth: a representation of well-being and pleasure

The general definition of psychological comfort requires a frame of reference; in this context, psychological comfort is used with respect to changes in delivery brought about by digitalisation centred in collaboration. People require to learn as a result of the new blend of skills required by changing processes from project innovation (Owen et al., 2010), therefore testing their individual ability to deal with new ways outside their comfort zone (e.g., can invoke feelings of discomfort which must be reduced). From psychology, it is argued that people act on intentions to reduce the risk of discomfort (Festinger, 1962).

2.6.6 Intrinsic and Extrinsic Motivation

Regarding incentives and performance, there is an oversimplified outlook in CM domain literature (Bresnen and Marshall, 2000b). Bresnen & Marshall (2000b) recognised that the incentives are arranged between project organisations and not between individuals who collaborate; the equity and reward is different for the individual and the company. This means that focusing on the procurement arrangements to study motivation does not show a complete picture, as it is argued here that the individual motivation factors need to be studied too.

Extrinsic motivation is understood as systems of reward (Kruglanski, 1978; Amabile et al., 1994). Whereas intrinsic motivation is defined as the extent to which an individual engages in an activity and is excited about a task (Amabile, 1983; Shalley et al., 2004). Intrinsically motivated individuals are more likely to be curious, cognitively flexible, risk takers and persistent, bringing about contributions to the innovative and creative performance of the team (Shalley et al., 2004).

Rose & Manley (2011) finds that the financial incentives are less important to motivation and performance than relationship enhancement initiatives. Three main types of financial incentives are used; sharing of savings, schedule incentives and technical performance bonuses (Bower et al., 2002).

There is a significantly large collection of literature in the application of financial incentives in the context of individual psychological processes (Deci, 1971; Bandura et al., 1999), and motivation of employees in organisations (Locke and Latham, 1979; Hackman and Oldham, 1980; Katzell and Thompson, 1990). The motivational outlook within inter-operational level between teams in a construction project are under-represented as the environment is not of the same nature (Rose and Manley, 2011).

Chen & Kanfer (2006) finds a parallel between individual motivations and team level motivation. This also represents the difficulty in assessing performance as the highly interdependent teams make individual output indistinguishable from group output (Howard et al., 2002). Another reason for not making this reductionist assumption is that the organisations are extrinsically incentivised by contracts, and individuals working on the projects are extrinsically incentivised by the firm (Mullins, 2007; Osabiya, 2015).

Bresnen & Marshall (2000b) finds the following:

1. Incentives and motivation are often implemented in a piece meal manner contradicting the overall need to modify behaviour
2. Subjective nature of equity and rewards
3. Different motivational implications on company and individuals
4. Motivation and commitment are from intrinsic and extrinsic rewards

Clashes between the profit of the firm (extrinsic) and digitalisation/innovation needs at the project level (intrinsic) are found from an exploratory critical realist study (Barrett, 2018).

2.6.7 The Role of Trust and its Indicators

Team integration is seen as an important part of strategy to facilitate and improve the cooperative and collaborative project level environment (Egan, 2002). Trust is said to be fundamental in human interaction making it significant in collaborative environments such as in AEC projects (Lechler, 1998; Gad and Shane, 2014). Trust between project level participants is explained to be inherently linked to information sharing and therefore information latency (Wood et al., 2002). Many studies link trust with collaboration and project management success (Bond-Barnard et al., 2018). Openness, dependability, integrity, fairness, and attitudes are all indicators of trust (Pishdad-Bozorgi and Beliveau, 2016).

Trust enables achieving efficiency in solving sophisticated tasks and project success as it brings a collaborative environment (Wong and Cheung, 2004; Wong et al., 2005). Trust is said to facilitate alignment of partner interests (Atkinson et al., 2006). The benefits of trust include reduction in exchange costs between businesses (Wood and McDermott, 1999). Trust is defined as the interacting parties' mutual confidence apparent when the exchange could expose vulnerability (Sabel, 1993; Coleman and Coleman, 1994).

The types of trust are presented in Table 3.

Table 3: Types of Trust (Pishdad-Bozorgi, 2012; Pishdad-Bozorgi and Beliveau, 2016)

	System Based Trust	Cognition Based Trust	Affect Based Trust	Context Based Trust
Definition	Compliance with the organisational communicational and commercial defined by the systems in place	Perception of other stakeholders' level of trustworthiness	Emotional intelligence developed as a result of long-term personal relationships	Constrained circumstance that makes stakeholders trust one another to proceed
Examples of ways it is achieved	Team building, mutual shared goals, collective decision-making, open communication, clearly defined contract, relational contract, shared risk and reward	Work related interaction, information sharing, behaviour and interaction of partners, open dialogue and transparency, collaborative and cooperative culture, similar culture and value, reputation and experience	Mutual understanding, showing care, consideration of other's needs, personal relationships, long term relationships	External circumstances to drive trust

A number of studies have related various procurement routes to the way teams trust one another (Kumaraswamy et al., 2005; Laan et al., 2011; Guo et al., 2013; Gad and Shane, 2014; Che Ibrahim et al., 2015) however, it is more complicated than just having a contract or business model that incentivises trust (Strahorn et al., 2017). The study of alternate procurement routes in relation to the trusting relationship between clients and contractors exist (Kumaraswamy et al., 2005; Laan et al., 2011; Guo et al., 2013; Gad and Shane, 2014; Che Ibrahim et al., 2015). An emphasis on developing trust by relational contracting (Goddard, 1997; Rahman et al., 2007; Rahman and Kumaraswamy, 2008; Doloi, 2012) and alliances in projects (Davis and Love, 2011; Chow et al., 2012; Walker and Lloyd-Walker, 2016). Zhao, Feng & Li (2018) found that mutual trust in an enabler for moderation of contractual complexity. Additionally, it is inevitable that even though the relational contracting route is found to be more conducive to developing trust, it is not guaranteed; further reiterating the need to consider the constituents of the collaborative environment from non-contractual aspects.

Trust is also described as an individual phenomenon and is argued to be most efficiently studied through the 'lived experiences' of people involved (Strahorn et al., 2017). The existing relationships between individuals in different teams were found to be beneficial in terms of trust and it's indicators (Buvik and Rolfsen, 2015). Effective teams are shown to exhibit good working relationships enabling less conflicts and therefore better chances for success (Che Ibrahim et al., 2015). The 'interaction environment' between teams was related to innovation participation; more

aggressive environments resulting in testing the strength of trust means likely less participation or vice versa (Barrett, 2018).

The cultural inconsistencies, distrustful relationships and design-construction divide in the project team are recognised as inhibitors to the ability to perform in an integrated manner (Cicmil and Marshall, 2005). The attitudes stemming from differences in culture between individuals at the project level and groups at the national level require investigation between organisational, national and project culture (Phua, 2013). Barrett (2018) explains the distinction of cultures between professions as being an important aspect that affects their behaviour at the project level. By increased understanding between one another in a social situation team cohesion and trust develops (Maurer, 2010). Mistrust between individuals leads to conservative behaviour and dysfunctional relationships resulting in conflict and individuals protecting their own interests (Pishdad-Bozorgi and Beliveau, 2016).

2.6.8 Summary of the Psychological and Social Aspects of Collaboration

This section provides a detailed view of phenomena relating to the people part of the IDDS model. The in-depth view of literature was driven by the emergence of the people oriented phenomena in the main study in this research. Furthermore, it represents a gap in CM domain literature where people oriented phenomena are not discussed to this level of detail. By understanding these phenomena, in this thesis, these aspects are used to reflect and understand collaborative practice in AEC industry.

2.7 Comparison with Similar Industries

The AEC industry is generalised as a Project Based Inter-Organisational Network (PBION) similar to the film, health care and defence industries (J.E. Taylor, 2005). In Section 2.7.1, a comparison of project collaboration literature from film and AEC industry delivery was utilised to draw key phenomena. The health care (see Section 2.7.2) and defence (see Section 2.7.3) industries were used to bringing approaches taken in industry and academia to facilitate practitioner understanding of the complexity of collaboration in practice. This is also endorsed by the recent report from the Centre for Digitally Built Britain (CDBB) who state:

> *'there is much to be learned from other sectors such as aerospace, defence, offshore oil and gas…' (Neely et al., 2019, p. 31)*

2.7.1 Film Industry

The history of innovation in the film industry could provide numerous examples of occurrences where disruptive innovations have altered organisational management.

A key difference between the industries is the economic and social climate. Significant changes occurred in the film industry between the 1950s and 1960s where major studios disintegrated into be-coming only financiers and distributors as compared to their original role, which involved every stage of the film making process. These changes in organisational structure allowed for changes in contractual arrangements between organisations where annual contracts

became project-based contracts. When analysing these two industries, it is critical to keep in mind the economic and social conditions of the environment at the time of innovation occurrence, as historical events such as the Second World War and rise of TV had direct affects how global industries share resources.

A typical film project would be orchestrated by a producer, who would have the knowledge to decide how the network is organised (Windeler and Sydow, 2001). In the AEC industry, it seems that no one stakeholder manages change, although the client is often the driving force behind systemic change (Brandon, 2006). The client is directly involved in the whole process; however, a client is viewed as an agent who does not have enough knowledge or incentives for innovative solutions. The producer in the film industry holds a position as a client does in the AEC industry, but, contrary to the construction client, the producer is involved directly at each stage (Watson, 2004).

One of the critical differences is how projects are funded and earn money. The stakeholders in a construction project are typically funded based on progress towards project completion. The additional income they have is through enforced or intentional change orders. However, in the film industry, the stakeholders are funded depending on the income of the film which depends on the many thousands or even millions of end-users. This is a critical difference as this changes the motivation of individual stakeholders towards delivering a project successfully. In the AEC industry, the production process is oriented around just one client, the assigned schedule and the allocated budget; how well the project will generate money to the client is not affecting the reward of the project team.

Organisational practices in the film industry tend to be driven by the need to collaborate, which is a shared interest because of the financial incentives. On the other hand, in the AEC industry, the need to collaborate is in contradiction to the dominating contractual practices which do not incentivise collaboration, which may be due to the difference in incentives with respect to the funding structure.

Section 2.7.1.1 provides a comparison of industry using integration, fragmentation and transaction costs as phenomena. Section 2.7.1.2 shows a comparison of the use of tools in both industries and Section 2.7.1.3 applies social theory to explain the trends found.

2.7.1.1 Common Phenomena in Forms of Procurement: Fragmentation and Transaction Cost

Two types of delivery methods from the film industry and AEC industry were compared respectively; From the film industry, 1) studio and 2) independently produced films is compared to 1) traditional Design-Bid-Build (DBB) and 2) the Integrated Project Delivery (IPD) from the AEC industry. The studio produced film was made within the one studio organisation whereas the independently produced film involved outsourced services. The DBB delivery method is one that involves a highly fragmented environment predominantly due to the separate social entities

in design and construction. On the other hand, the IPD is a delivery method that aims to share risks and gains between all the stakeholders (AIA, 2007).

Robins (1993) validated the comparison of a studio-produced film to an independently produced film by Warner Brothers. He reiterated the rarity of this form of data as projects in PBIONs are highly subjective and therefore cannot be compared normally. It should be noted that the derivation of phenomena from the film industry is based on this one study.

Fragmentation in the film industry is motivated by cross fertilisation of ideas. Both construction and film are incentivised in eliminating high fixed costs of in-house resource/expertise. Fixed costs are due to standby specialists that have to be paid when there are no projects running.

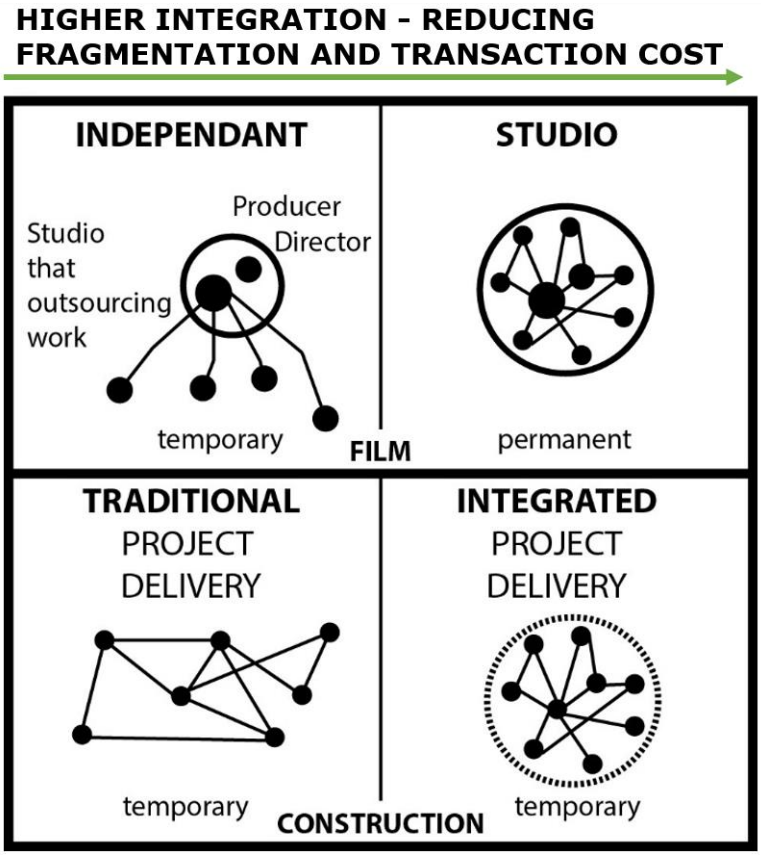


Figure 12: Procurement in Film and Construction (S. F. Sujan et al., 2016)

From comparing the delivery methods (see Figure 12), the fragmentation of IPD and Studio are much less than independently produced films and traditionally delivered projects, however, it should not be mistaken that the studio produced film has the same form of fragmentation as the IPD form of procurement. When reflecting, one should note that the nature of the projects of both industries differ due to the differences in business model, culture, nature of product and therefore a solution in one industry cannot be transferred to the other one directly. However, people are interacting similarly, therefore, common phenomena can be drawn to provide an effective reflection.

Robins (1993) study concluded that the independently produced film cost more to produce than the studio produced film, however, independently produced films are typically more successful. Robins related transaction cost theory to fragmentation to help understand why the more fragmented delivery method costed more. Transaction cost theory (Coase (1960) explains the higher cost of having a service outsourced as one that is due to the increase in social interaction. Therefore, a higher level of fragmentation would stipulate more social groups interacting. This means that there would be a higher transaction costs associated, and the magnitude of transaction costs is proportional to the fragmentation and therefore also to social interaction.

Figure 13 shows the common elements that motivate PBIONs to be more integrated or fragmented. The film industry in the 1960s disaggregated production to support cross fertilisation of ideas to produce more successful films as small specialist companies are more agile (due to fewer bureaucratic barriers) to the constant changing market needs such as technological changes and generation of new ideas. However, when considering these, we need to consider that motivation towards collaboration could be different as the nature of the product in both industries differ.

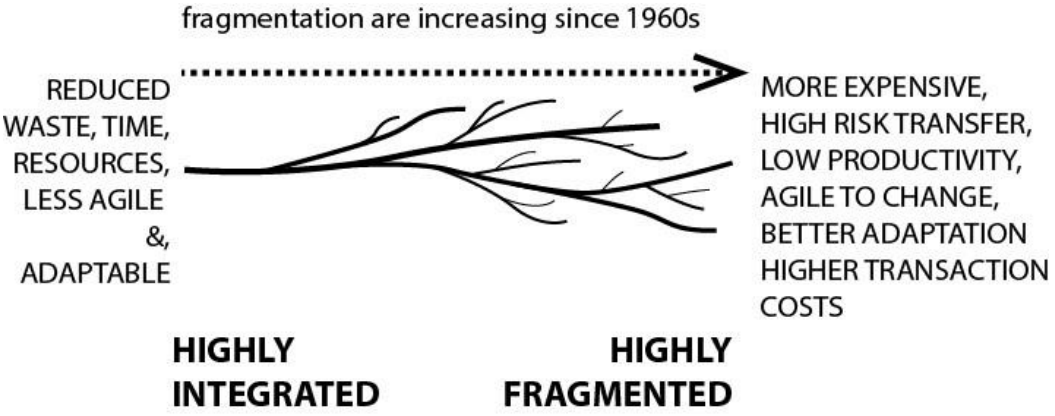


Figure 13: Motivation to Fragment or Integrate (S. F. Sujan et al., 2016)

While in the AEC industry, the process of fragmentation is happening naturally, the industry practices are conservative and inefficient. Figure 14 shows the characteristics of highly integrated and highly fragmented practice.

Various researchers discuss fragmentation as a problem; this goes against the low use of the highly un-fragmented procurement method – Integrated Project Delivery (IPD) which is designed to support collaboration and implementation of systemic change. Becerik-Gerber & Kensek (2010) investigated the slow adoption of IPD. Findings suggest that there is a high degree of concern regarding risk in relation to IPD as legal frameworks need to be devised.

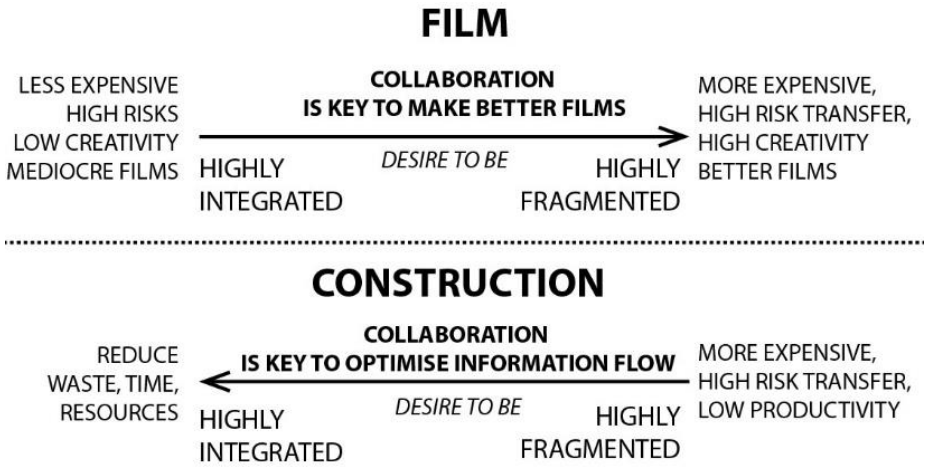


Figure 14: Characteristics of Highly Fragmented/Integrated Practice (S. F. Sujan et al., 2016)

Broger (2011) concludes that the more fragmented method (independent) is less cost effective than the less fragmented method (studio). Applying transaction cost theory; the more services run through the market means more transaction cost and since high fragmentation means more separate entities working with one another; this leads to a higher overall transaction cost. In a highly fragmented environment, such as independent film making, there are more transaction costs and since the highly fragmented method is less cost-effective; it would be valid to conclude that increased fragmentation would mean increased cost of production due to higher transaction costs. However, it is important to note that fragmentation allows for lower fixed costs and therefore suggests that for a management system to be effective, fragmentation cannot be disregarded.

2.7.1.2 Historical Development of Tools in the AEC and Film Industries

The AEC and film industries heavily rely on the use of technologies in practices. From the historical perspective it is clear that technology plays an important role in driving innovation.

The film industry is a constantly changing industry that started with a technological revolution when Thomas Edison introduced the phonograph in 1877 (Encyclopædia Britannica, 2016). The following significant systemic change was Edison's introduction of the kinetoscope in 1894. A year later, the Lumière brothers introduced the first commercial projector. On the contrary, the AEC industry is considered to be long established. Major innovations, such as moving from hand drawing to 3D CAD, have been introduced to design and construction incrementally meaning that changes were not considered integrally but independently.

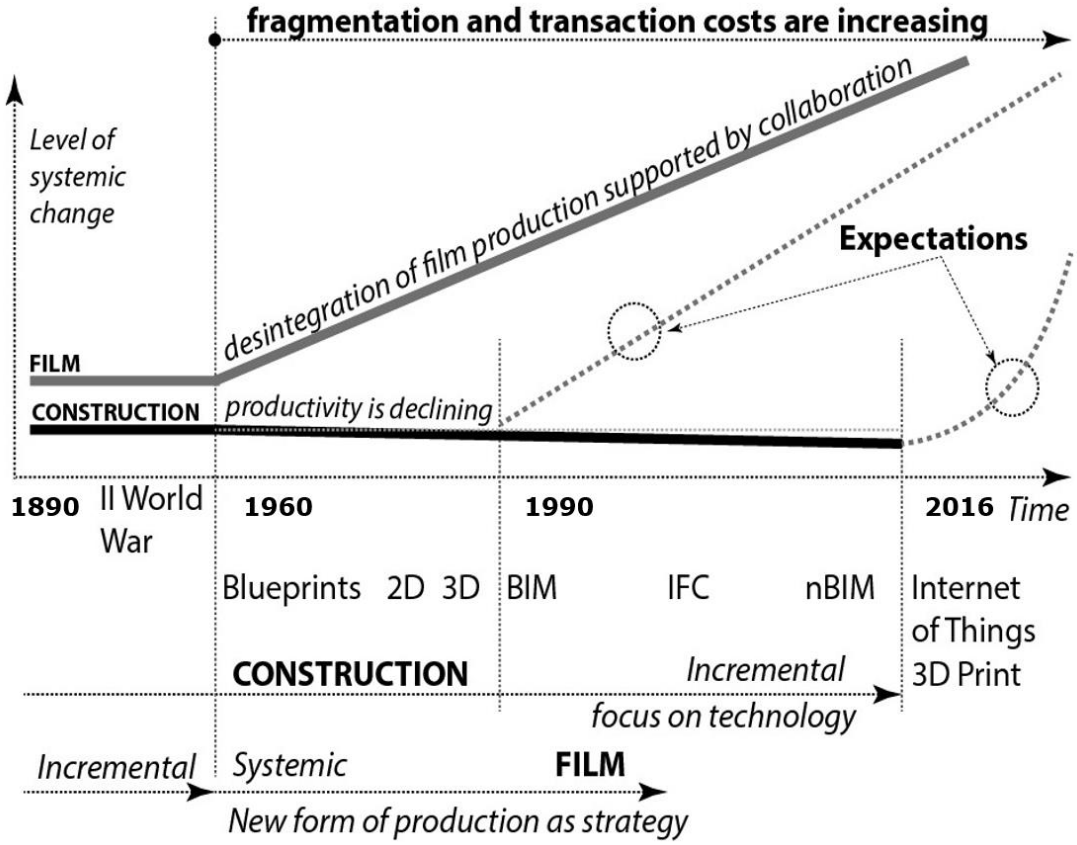


Figure 15: History of Technology Advance in Film and AEC Industry (S. F. Sujan et al., 2016)

As illustrated in Figure 15, the film industry in the 1960s had an urgent need to distinguish itself from the television industry, which allowed people to watch from their homes. Film production was driven by the need to make films that can compete with TV. It had to innovate by adopting new technologies supported collaboration, which made systemic change in how films were produced. This change brought about the need for a more fragmented PBION. Recently, new technologies allow the film production process to become widely distributed, as it is not necessary to have all the people in one single location. Currently film production is tending towards post-production to minimise the need to use physical objects.

At the dawn of the 21st century, the film industry was one of the fastest growing industries (U.S. National Archives and Records Administration 2001). Recently published statistics from the US Department of Commerce also show this form of growth. Figure 16 was developed to show the cumulative growth from 2008 to 2014 for both industries based on value added to the US economy.

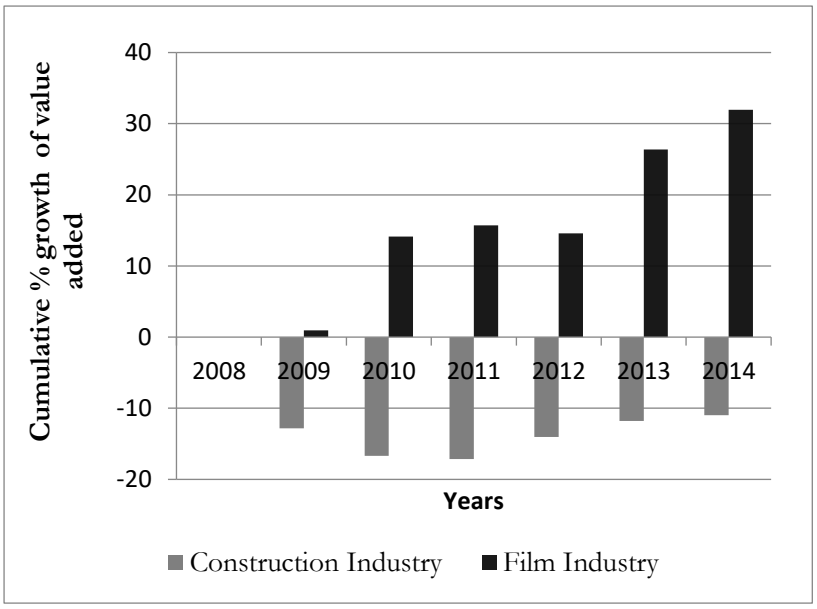


Figure 16: Cumulative Percentage Growth of Value Added to US economy (U.S Department Of Commerce, 2016)

The AEC industry has seen several technological changes that have not brought dramatic improvements. The industry was expected to change with the introduction of BIM in the 1990s. Several decades have passed and the industry's productivity was still in decline (Teicholz, 2013). This is further supported by Figure 16, which shows the negative cumulative growth of construction since 2008. On the other hand, the film industry shows positive cumulative growth.

2.7.1.3 Application of Social Theory

Broger (2011) argued that the dualism presented by structuration theory is grounded in the fragmentation of the field concerned. This generalised viewpoint adds to the validity of the application of structuration theory to the highly fragmented film and construction industries.

It is established that in the film industry, the producer is typically one of the agents throughout the project who leads the process. On the other hand, in the AEC industry, the agents vary depending on the stage of the project; there is usually no agent that is involved throughout the whole project, for example, in most traditional contracts the contractor (an agent) is not involved in the scope design.

This notion can be related to Taylor's claim in having integrated practices, which would allow companies to establish long term relationships. Long-term relationships would allow for transfer of knowledge and new practices from one project to another that these relationships exist in.

On the level at which stakeholder groups inter-act, structuration can also be applied. Windeler & Sydow (2001) explained the need for an inter-organisational practice, which has form-specific rules and resources (that control the social structure) produced by knowledgeable agents. It should be noted that the inter-organisational practice is both process and product oriented which means that it considers both process of utilising tools as well as how people collaborate.

Similar phenomena derived from these industries with respect to systemic change are that of fragmentation and transaction cost. These phenomena can be directly linked to the social theory of structuration. However, structuration theory's major limitation in this application is that of a highly abstract concept not considering the activity within the system, nor the individuals that are capable of change. Since fragmentation is an important theme in this research, it is not suggested to ignore structuration theory but to fill the gap associated with structuration theory by the use of CHAT. The validity of the synthesis of these two theories is justified; Giddens (1986) states that structuration theory must be applied both in a micro and macro perspective (considering changes between activities in inter-organisations and accumulated changes that the system becomes familiar too). In this application structuration theory is to be used to explain accumulated changes (macro-perspective) by various agents and how that affects structure. CHAT considers interaction of multiple activity systems and distribution of knowledge and learning between various proponents of the system and tools used, such as implementing a BIMM tool, should affect existing structure, for example, rules and division of labour that are devised by both contractual relationships and procurement methods. In other words, the synthesis of the two theories in application to systemic change in project based inter-organisational networks can provide a valuable integrated perspective.

2.7.2 Health Care Industry

The health care industry requires inter-professional collaboration between specialists and nurses to enable effective solutions for patients. As a result of direct impact on human life, there is a lot of literature in practice-based collaboration (for example; Henneman, 1995; C & Strype, 2009; Ødegård, 2006; Strype *et al.*, 2014). Furthermore, there are discussions in literature about the use of the current biomedical model which is more focused on the physical (pathological) aspects of a patient (Wade and Halligan, 2017). The biopsychosocial approach (Engel, 1981) was introduced in 1977 as a result of the practice of lacking holistic thinking of the biomedical model but is still not widely used (Wade and Halligan, 2017). The biopsychosocial approach provides systematic consideration of the complex interactions between biological, psychological and social factors in understanding illness and health care delivery (Engel, 1981). In the exchange between a patient and the health care team, trust is central (Zhixia and Mengchu, 2018). To show the non-tangible aspects involved in health care practice, a model with interacting systems was developed shown in Figure 17. The biomedical model has brought about practice that is overly focused on pathology, although there are other systems that affect the overall health care solution. The dependency on human psychological and social aspects is evident from the number of non-directly observable aspects.

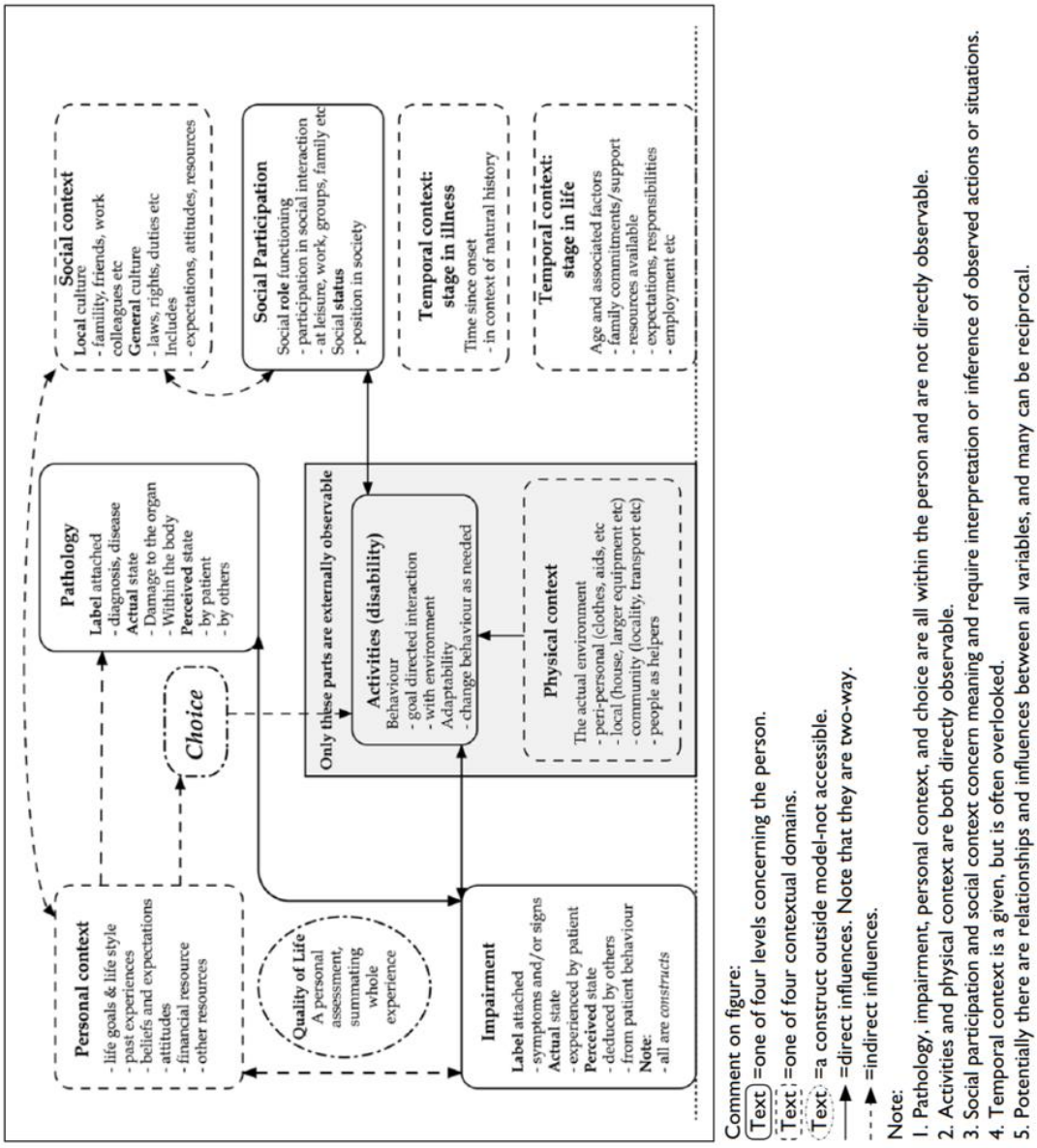


Figure 17: Holistic, Biopsychosocial Model of Illness (with permission of Wade & Halligan, 2017)

2.7.3 Defence Industry Human Factors Integration (HFI)

Similar working industries (e.g., aviation and defence) that have a higher direct risk to human life recognize the importance of human factors regulation and have developed complex tools that guide practitioners to develop processes and workflows that are within human capability.

In the context of NASA, an aircraft (asset) in operations pertains errors from all the participants since the conception of the asset to the final use (Adelstein et al., 2006). The human error consideration is regulated by governing standards and policies.

The performance of humans is recognized as a key factor in the overall system performance; enhancements to human performance reduces lifecycle costs (USDOD, 1999). Human factors integration (HFI) is treated with importance throughout the lifecycle of an asset even in operational management (Shorrock et al., 2004).

It is acknowledged that similar tools and methods are used in HFI in different domains of applications, these tools include scenario-based requirements capture (Gregoriades and Sutcliffe, 2006) and top-down requirements analysis (MacLeod, 2008). The use of these tools is to enhance consideration of HFI early in the project process. Other tools include NASA's 'Initial Human Error Hazard Analysis' which involves understanding the links between human capability and system requirements, enabling the considerations of human limitations in developing processes to execute. Figure 18 shows an abstract structure of the HFI model used by UK DOD.

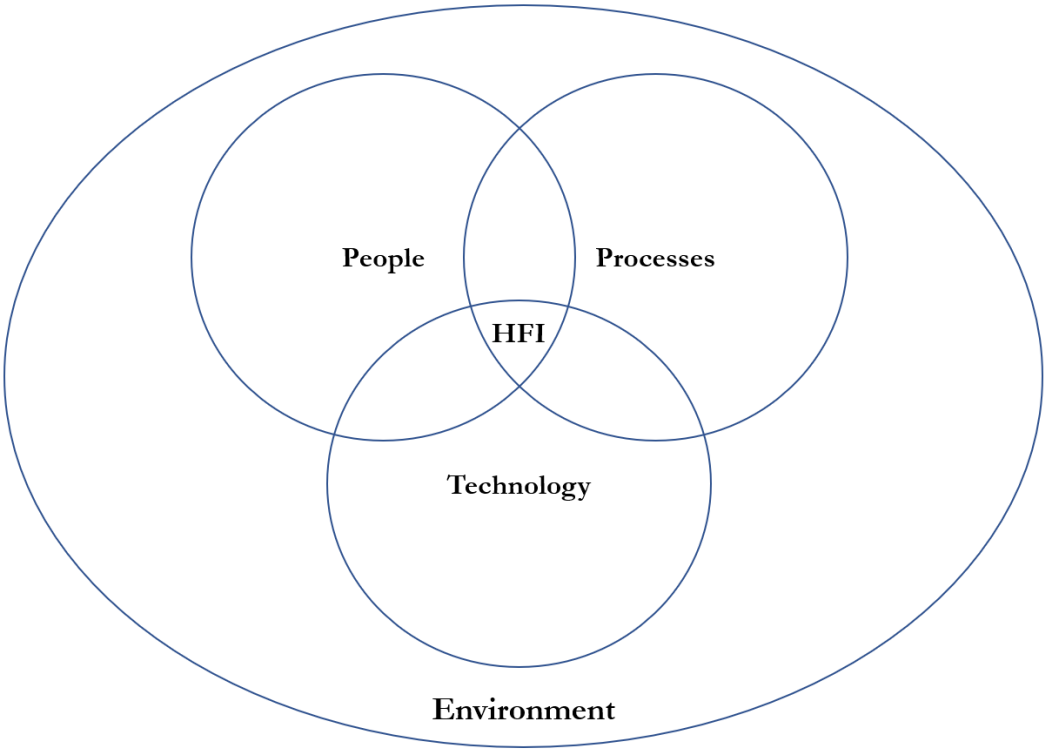


Figure 18: HFI Abstraction (Adapted from Ministry of Defence, 2015b)

Processes and technology are defined similarly to the IDDS, However in the HFI, people are defined as the personnel and support staff who 'operate, manage and support capability' (Ministry of Defence, 2015b: p. 1), perceived as a component of capability. The people, process and technology are to be managed considering the environment in which capability will be operated. The environment is the external conditions that affect capability of people, process and technology.

It is declared in the HFI standard that human physical, cognitive, psychological and social limitations require mitigation (Ministry of Defence, 2015b).

The regulation has the following key constituents where it clarifies and defines:

- Staff responsibilities
- Resource competencies: awareness of the human factors is listed as a competency
- Behaviour and conduct
- The way system requirements are defined and tested

2.7.4 Methods to tailor the process Summary of Comparison with Similar Industries

A comparison with similar industries provides an effective way to understand phenomena surrounding inter-disciplinary collaboration in other contexts. It also gives an understanding of how the human-oriented aspects are managed and considered in other sectors. From the comparisons with defence and health care industries, it is clear that these industries are at a higher level of maturity compared to AEC industry in research on the human oriented aspects.

2.8 Discussion

Even though the awareness of the importance of collaborative behaviour is made clear over the past few decades, adversarial culture and relationships is still a current challenge (Loosemore, 2013; Elmualim and Gilder, 2014). Although research and reports explain the need to reform and change the industrial practice, the normative challenges suggest that reform has not substantially occurred; the behavioural attributes bringing about disputes and inefficiency. Literature suggests that human behaviour and collaboration is the product of complex information exchanges at the project level and other external factors that are not well understood (Alperen, 2016).

Numerous authors point out that the AEC domain literature focuses on the technical or operational aspects, with less attention given to behavioural or social scientific approaches (Koskela et al., 2002; Baiden et al., 2003; Emmitt and Gorse, 2006; Shelbourn et al., 2007; Barrett et al., 2008; Forgues and Koskela, 2009; Keeble Kululanga, 2009; Phua, 2013; Sunding and Ekholm, 2015). There are also calls for more holistic approaches to grasp realistic concepts (Phua, 2013). For example, the existing literature on lean construction is overly prescriptive with low recognition of the social and psychological aspects (Green and May, 2005). It is argued whether traditional studies in project management practice pay enough attention to discovering the root causes of management challenges (AlSehaimi et al., 2012; Sunding and Ekholm, 2015). These studies suggest the use of action research to penetrate multiple levels of cause and effect to find root causes of practical problems. Therefore, the gap can be filled by a holistic multi-level perspective reflecting practice-based interactions between multiple causes and effects brought about by non-reductionist philosophical approaches; switching from structured operational to unstructured behavioural focus (Hugill, 1998; Love et al., 2011). Therefore, the aim departing from literary findings, is to understand the interaction and behaviour of people as a multilevel social entity (van Amstel et al., 2016).

There is a gap between knowledge established in academic research and the actual demands of real-life practice (Moum, 2008; Volker, 2019). Critique of the traditional research approaches to address the complexity and uncertainties of practice is not new, Schön (2017) explains the need to move from technical rationality to reflective approaches.

Moum (2008) and Barrett (2018) provide a detailed outlook on designer collaboration and innovation, however, united understanding in the AEC industry considering exchanges

between designer, contractors, clients and project management is needed. The current academic knowledge appears to be fragmented between the project phases and concepts; research is mirroring practice and therefore appears to be siloed (Smyth et al., 2019) resulting in the reductionistic approaches commonly used. Digitalisation in the AEC industry is leading academics to use more social scientific approaches (e.g., Volker, 2019; Barrett, 2018) as technical aspects are well covered (Hjelseth, 2017). Furthermore, literature also suggests a gap in the methodology to study dynamics of innovation as researcher 'do not have the methodological equipment to explore the particular dynamics of innovation in project-based firms, because they fail to draw a link between project and business processes' (Gann & Salter, 2000: p. 970). Therefore, the research gap that primarily applies to this thesis is addressed by synthesising the fragmented academic concepts relating to project level collaboration using real-life perspectives from industry using a social scientific approach.

From a recent report by the Centre for Digital Built Britain (CDBB), a research framework developed has seven categories; stakeholder value, services, built environment, data, governance, learning/adaptation, context/drivers (Neely et al., 2019). The most applicable category to this thesis is stakeholder value since the focus is on people in collaborative environments, and crucially this specific category has little research activity. Under stakeholder value, it is proposed to develop (Neely et al., 2019, pp. 28–29):

1. Explanatory and integrative frameworks
2. Tools to support procurement
3. Business models for digital built Britain.

In light of these research gaps, developing an explanatory and integrative model is necessary. Within this research, where a critical realist philosophical paradigm where an subjective view of an objective reality is presented, it can be seen that the literature is fragmented. Therefore, the literature review's topics were aligned to the model developed in this thesis which had a point of departure using the IDDS model. In summary, the findings of the research played a vital role in the development of the content of this literature review.

2.9 Summary

Relevant existing knowledge was reviewed with respect to the needs from the sub-research questions (see Table 1). A summary of how the needs of the research questions are met is shown below:

- **SRQ1** (Can project level collaboration be measured?): The insufficient measurement techniques of social and psychological indicators within the CM domain despite the discussed importance of social climate, suggesting the need to seek approaches from the health care industry. This finding was a primary motivation in the development of the exploratory study presented in Chapter 3. Literature utilised to develop the quantitative tool can be found in Section 3.2.

- **SRQ2** (What methodological paradigms are suitable to understand the reality of project level collaboration?): There are insufficient explanatory studies in CM literature that study project level collaboration considering the interdependent perspectives of designers, contractors and clients. Aspects regarding practice cannot be isolated but studies for potential influence on sector technologies and people (Owen et al., 2010). The simplicity and broad departure point adheres to the non-reliability of reductionist science, it cannot be assumed to be simplified to a sum of constituent parts, fragmented knowledge cannot be combined easily (Vandenbroeck et al., 2014; Sujan et al., 2019). There is need for more holistic approaches to studying CM reality (Phua, 2013). The use of qualitative data (see Section 4.6) and the validation techniques (see Section 4.8) are explained in the methodology chapter.
- **SRQ3** (What factors affect project level collaboration according to project level practitioners?): The fragmentation between designer and practitioner collaboration appears to be reflective in the literature (Smyth et al., 2019), there is significantly more holistic research in designer collaboration. However, with contractor collaboration, there appears to be fragmented dominant independent focus on procurement, sub-contractor selection and performance. This presents a research gap to incorporate the understanding of collaboration incorporating the exchange between contractors and designers. For this reason, the methodology developed considered all major perspectives in the project lifecycle.
- **SRQ4** (How can the factors that affect collaborative environments be visually interpreted?): Micro, meso, macro levels used in literature widely as a frame of reference of reality (Sections 0 and 2.2.3)
- **SRQ5 (**Which factors are most practical to change and impactful in driving industry wide change to suit project level collaboration and implementing digitalisation?): This did not involve any direct use of knowledge from literature; however, literature played a role in the researcher's understanding.
- **SRQ6 (**How do expert views from literature and practice compare to project level views?): Literature was used in comparison to findings in Sections 7.5.2 and 7.5.4.
- **SRQ7** (How are factors rooted in Human Psychology and Culture (HP&C) valued in the AEC industry compared to similar industries?): Similar industries backed by Taylor's generalisation of PBIONs including defence, film and health care. Each of these industries are looked at the way that human factors are dealt with in relation to collaborative solution development. Lessons are taken from these industries and comparisons made with the AEC industry.
- **SRQ8** (How can AEC collaboration models be adapted to suit realistic nature of factors?): Literature reviewed of collaboration models in both AEC (IDDS - Sections 1.1

and 2.2.2) and defence (HFI - Section 2.7.3) industries were utilised to show the need for a foundational level.

- **SRQ9** (How are the psychological and social aspects affecting project level decision-making and collaboration at the meso level?): Breaking down decision-making process to depend of beliefs (Section 2.6.1.2) from psychological theory was used and connections made to cognitive/motivational biases (Section 2.6.1.1). Structuration and CHAT (Section 2.6.2) combination generalises the analytical approach used to comprehend practitioner experience. Developing a structure of knowledge and/or principles and considering the activity between these phenomena from practitioner data was the basic process of deduction and induction. The biopsychosocial approach (Section 2.7.2) shows the dependency on human phenomena.
- **SRQ10** (How is the meso level affecting the mentality of collaboration and implementation of digitalisation at the project level?): Literature considering influence from client factors (see Section 2.5), contracts and procurement (see Section 2.4) on project collaboration and use of technology is used in sense-making process.

3. EXPLORATORY STUDY

3.1 Introduction

This chapter summarises the design, methodology, analysis and results of the exploratory study. The primary aim of the exploratory study was to answer SRQ 1 (Can project level collaboration be measured?) by developing a metric to measure collaboration and validate it using a qualitative study. The mixed methods exploratory project played a crucial role in selecting the methodology of the main study (SRQ 2), it gave the researcher experience and knowledge in holding interviews and deeper insight into the reality of collaboration. The geographical location of the study was Lusaka, Zambia, where the researcher has experience working.

Various studies have developed methodologies to visualise collaboration efficiency statistically in similar industries using perception of teamwork environments. In the methodological design, this was considered. As people are the centre of activity in Project Based Inter-Organisational Networks (PBIONs), using practitioner perceptions and experiences is therefore relevant in CM research regarding collaboration. PBIONs such as the AEC industry are categorised to work similarly in industries such as health care, aerospace, defence and film (J. Taylor, 2005).

Section 3.2 explains the logic and literature used to design the Quantitative Instrument (QI). Section 3.3 explains the methodological aspects including the sampling strategy, participants and ethical approval. Section 3.4 explains the quantitative and qualitative results in a cohesive manner centred by the main factors found in the qualitative part. Section 3.6 discusses any potential limitations of the exploratory study. Section 3.5 provides concluding remarks that were considered in the development of the main study's method (see Chapter 4). The objective of this chapter is to conduct a mixed methods study to assess and validate a quantitative tool developed from an evidence base, intuition and literature from similar industries to assess project level collaboration (SRQ1).

3.2 Quantitative Instrument (QI) Development

A QI was developed with the purpose to measure collaboration between project level participants. The design of the QI included:

- General information (Part 1); aimed to capture the age, firm occupancy length, gender, profession, experience, preferred contract, level of technology used and whether the participant is in direct contact with other teams,
- Teamwork environment (Part 2); further discussed in Section 3.2.1,
- Systemic risk (Part 3); further discussed in Section 3.2.2,
- Personality (Part 4); further discussed in Section 3.2.3.

3.2.1 Teamwork Environment (QI Part 2)

From similar industries, three different studies with the same underlying philosophy were considered in the methodological development. These studies consist solely of quantitative data due to the achieved high statistical validity. However in the context of practitioners involved at the project level of a single construction project, statistical validity would be lacking; other means of internal validation is required, qualitative methods were adopted (Clark and Watson, 1995).

Sexton *et al.*, (2006) conducted a study on the teamwork climate in labour and delivery units, which means all people involved were a part of the hospital the study was carried out in; similar to the Integrated Project Delivery (IPD) way of working where there is increased integration from shared risk and reward.

Similarly, from child mental health networks (primary, specialist and school carers) a study was done based on a method previously developed by Ødegård (2006) called the Perception of Interprofessional Collaboration Model (PINCOM-Q). The research was conducted on 96 mental health networks in order to see the difference in quality of collaboration between mental health professionals and mental health professionals in schools.

A similar study explains the use of PINCOM-Q to study collaboration in local crime prevention, involving various professionals from social welfare, education, police, health services, and so on. The sample of this study is of a similar nature to that of traditionally run projects in the AEC industry, as the disciplines are not governed by a group but are accountable to a client's case (Strype et al., 2014b).

From the three studies highlighted above, a combination of constructs was selected and adapted to suit construction project environments to capture the differentiating views about the project's environment. A seven-point Likert scale was used.

3.2.2 Systemic Risk (QI Part 3)

Systemic Risk in the context of the AEC industry is a novel concept, however it has been used regularly in the financial sector. A systemic risk is one that affects all the project teams' firms; thereby uniting their perception of the probability and consequences of the risk as they all stand to lose similarly. In this context by presenting practitioners with examples of situations that present systemic reactions, it is hypothesised that a project team collaborating better would have a more united perception of these risks.

Judgement of risk involves probability and severity, but when applied to systemic risks, severity is difficult to quantify (Ellinas et al., 2016). Therefore, in order to reduce the ambiguity of severity, three separate impact factors were introduced; 1) impact on a firm's cost, 2) impact on client's cost, and 3) impact on the project schedule. The participant required to input a number between 1 (low) to 5 (high) for both probability and impact.

3.2.3 Personality Constructs (QI Part 4)

Researcher experience and intuition suggest that personality plays a key part in collaboration. However, consideration of this has been sparse in the context of collaboration in the AEC industry. Barrick and Mount (1991) investigated the relationship between personal characteristics and job performance; positive emotional stability, openness to experience and agreeableness were found to positively affect participants' management performance. Generally, the personality is viewed as personal characteristics that do not change in the short term (Lucas and Donnellan, 2011). Personality formed a classification part of the Hannigan (1990) study of intercultural effectiveness. A patient, courteous, flexible attitude allowing a willingness to immerse oneself in the new environment is required (Hannigan, 1990).

In this study, the Neuroticism, Extraversion, Openness Inventory-Revised (NEO-PIR) was used (Terracciano et al., 2005); the copyrighted tool is an established personality inventory which examines an individual's Big Five personality traits (i.e., openness to experience, conscientiousness, extraversion, agreeableness, and neuroticism) using a five-point Likert scale. Internal consistency coefficients have been calculated at 0.86 for the form (self). While only three of the subtests have good long-term test-retest reliability (neuroticism, extraversion, openness to experience), all of them have high short-term test-retest reliability.

Neuroticism is a dimension that refers to the tendency to experience negative effects such as fear, sadness, embarrassment, anger, guilt and disgust more keenly. A low score in neuroticism relates to a person who is emotionally stable, meaning, for example these individuals would cope better with stress than high scorers.

Extraversion refers to traits such as sociability, assertiveness, activity and talkativeness. Extraversion is characterised by positive feelings and experience, which makes it a positive effect (Clark and Watson, 1995). A range of studies show that extraversion is a valid performance indicator in jobs characterised by social interaction. In the context of this study, this is valid as the AEC industry is ideally tending to a highly collaborative environment. For example, Johnson (1997) found a positive correlation between extraversion and job performance of police personnel. As outlined earlier, the police work in a transdisciplinary manner similar to the AEC industry making extraversion a potential important construct to consider.

Openness to Experience consists of active imagination, aesthetic sensitivity, attentiveness to inner feelings, a preference to variety, intellectual curiosity and independence of judgement. Those who score highly tend to be unconventional, willing to question authority and prepared to entertain new ethical, social and political ideas. Studies show that openness to experience is related to success in consulting (Hamilton, 1988), training (Barrick and Mount, 1991; Vinchur et al., 1998) and adapting to change (Raudsepp, 1990). Based on these findings and in the context of this exploratory study, technological change in the AEC industry would require and benefit from

individuals with 'openness to experience', as there is arguably a need to make changes in culture and existing ways of working.

A highly agreeable person would be fundamentally altruistic, sympathetic to others and eager to help them, and in return believes that others will be equally helpful. Judge *et al.*, (1999) concluded that the cooperative nature of agreeable individuals may lead to success in occupations where teamwork is relevant, such as in construction.

Conscientiousness involves self-control, the active process of planning, organising and carrying out tasks (Barrick et al., 1993). A person that scores highly is purposeful, strong-willed and determined, and would be ideal in an interdisciplinary environment as work needs to be planned ahead and information needs to be provided to other disciplines on time.

3.3 Methodology

Data collection involved both qualitative and quantitative methods, achieved by concurrent triangulation (Creswell and Creswell, 2018). The qualitative part of the study was implemented to assess support for the quantitative element in order to ensure that the quantitative data was comprehended with respect to reality (Fellows and Liu, 2015). The comparison of two projects' collaborative cultures involves low statistical validity due to the low number of team participants engaging in exchanges between teams at the inter-organisational level. The qualitative analytical strategy employed thematic analysis, a widely used method in psychological disciplines. Developed by Braun & Clarke (2006), the method involves the development of themes and codes. The emergent themes are used to structure the discussion (Section 3.4).

The use of convergent parallel mixed methods (Caldas, 2003) was carefully chosen in order to provide additional validity to the claim that one project was indicative of more collaborative than the other. The definition of the types of mixed methods is further discussed in Section 4.3.3. The approach was most suitable to 'theoretical replication' as the projects' team environments were contrasting – the primary reason for choosing both the projects. Although the application is different, the method adopted is similar in nature to a study reported by Kerrigan (2014). As widely used in the field of social psychology, human perception helps build mental structures about a theme which therefore helps participants relate the present experience with past ones (Bartlett and Burt, 1933); a form of reflection that can help the researcher understand the underlying complex factors involved in collaboration between teams.

Two of Zambia's largest mixed-use building construction projects were selected under the assumption that a larger project would have more participants involved at the project level. The scope of the study was limited to design teams as construction was at different stages. The method followed was that of a convergent parallel mixed-method with a 'replication' logic (Creswell and Creswell, 2018). Project A was a D&B project which involved a shopping mall and hotel. Project B was Design-Bid-Build and comprised of a multi-purpose educational facility.

Sampling strategy of both project and participants is opportunity and convenience based. The target was to provide a comparison on the collaborative cultures of two construction projects and it required that the participants were involved in project level collaboration; this was done with the guidance of the lead architects. The process of data collection adhered to and was approved by the ethics departments of the University of Liverpool (Approval Reference, 1614) and ERES Converge (local Zambian agency). The participants were required to consent to the use of the information provided after reading an information sheet; these documents can be found in Appendix B.

Sections 3.3.1 and 3.3.2 explain how the qualitative and quantitative data was collected. Participants who were interviewed (face to face) all completed a web-based questionnaire before the interview.

3.3.1 Qualitative Method

To strengthen validity, semi-structured interviews were utilised to verify and support the quantitative data collected by asking about the practitioner's personal reflections of the project's collaborative culture. Semi-structured interviews were selected because this approach allows questioning within a flexible framework, encouraging depth and the emergence of new concepts (Dearnley, 2005). The interviewer created an environment where the interviewee could explain the nature of collaborating in the project and was probed further as appropriate to obtain views to determine reasons for the claimed behaviour. The interviewer was also able to observe the behaviour of the interviewee when asked about project specific difficulties. Section 3.3.1.1 explains the participant backgrounds and their selection criteria. Section 3.3.1.2 explains the procedure of semi-structured interviews.

3.3.1.1 Participants

Project level participation was ensured by beginning the interview by asking the interviewee about their involvement in the project. If there was no mention of the interviewee having direct interactions and sharing information with other teams and/or the client, that data was discounted; to understand the collaborative nature of the project and be able to question it, requires perspectives of people directly involved in exchange of information and physical interaction. This was used as a selection criterion to exclude possibilities of less reliable accounts.

A total of 14 participant interviews were conducted, 6 participants from Project A, 7 participants from Project B and 1 participant who was involved in both projects. A breakdown of the backgrounds of the interviewees is shown in Table 4.

Table 4: Backgrounds of Participants in Exploratory Study

Background of Designer	Project A Frequency	Project B Frequency
Architect	1	1
Project Manager	1	1
Quantity Surveyor	1	1
Structural Engineer	1	1
Mechanical Engineer	1	1
Electrical Engineer	1	
Client Representative	1	2

3.3.1.2 Procedure

Appendix C includes the questions used to guide the researcher in the semi-structured approach. The interviews began with an introduction explaining the purpose of the research, i.e. to understand the collaborative culture between teams. This was facilitated by presenting the participant information sheet and consent form (see Appendix B). Once consent was obtained, the interviewee was asked to describe their involvement in the project to ensure involvement in project level collaboration.

To understand the participant and to begin developing thought processes about collaboration at the project level, each participant was asked to rate the project in relation to the most positive collaborative project they have participated in. Based on their rating, they were then asked why they rated it that way. Responses at this point varied and took the direction of the discussion towards other questions in the guide; this flexibility was one of the primary reasons for using a semi-structured approach.

The interview with the participant (electrical engineer) involved in both projects A and B comprised of questions that compared how different the projects were, which project was more collaborative and was probed with respect to the topics found in the guide. The participant also compared the projects e.g., their environments, leaders and how design changes were managed.

3.3.2 Quantitative Method

Quantitative data in the form of a web-based survey was collected asymmetrically. Opportunity and convenience sampling were used. Participants were recruited via the managing directors of the lead architect firms. In the projects, in order to ensure that each participant was involved at project level collaboration, Question 9 (see Appendix D) in the web-based survey was utilised; if the respondent answered 'no' to having direct contact with other teams, the response was discounted from analysis. Below are the participant numbers per profession for both projects after initial analysis was conducted. Although the statistical power seems insufficient, from Section 3.2.1 and 3.2.3, the method utilised in parts 2 and 4 of the survey are validated in similar industries with similar working inter-disciplinary environments (Ødegård, 2006; Strype et al., 2014b). Figure 19 and Figure 20 show the distribution of the participants between disciplines.

The low statistical validity of the quantitative data was also a reason for choosing a mixed methods based approach.

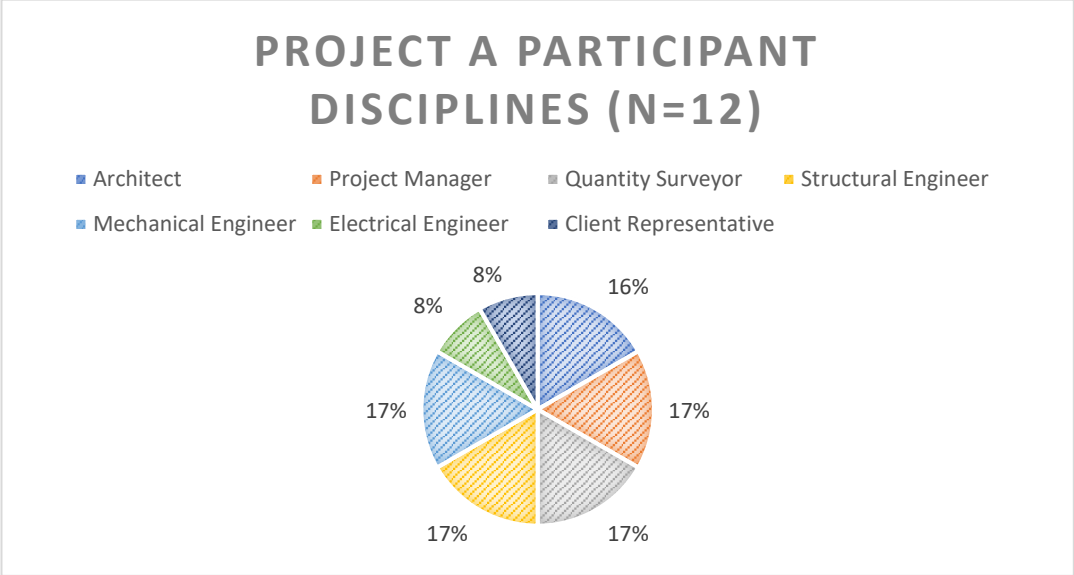


Figure 19: Participants Project A

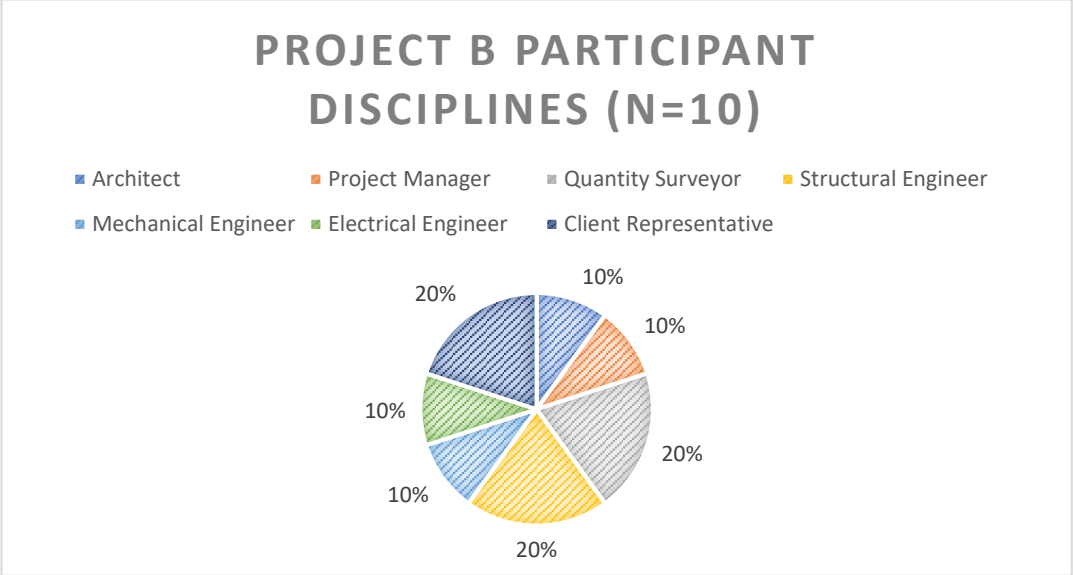


Figure 20: Participants Project B

The following are threats that are applicable to the study found by Creswell and Creswell (2018). Table 5 shows the suggested response and how the threat was prevented as part of the research design.

Table 5: Preventative Measures of Threats to Quantitative Validity

Threat	Description	Suggested Response	Prevention of threat
History	As time passes during an experiment, external events can occur that affect the experiment beyond the control of the researcher	Have both sets of participants endure the same external event if there are any disruptions	Consistent contact with the lead designer of both projects to know whether any significant external event has occurred. E.g., if a firm is dismissed from the contract, this would change the dynamics of the collaborative environment
Maturation	Significant time between interviews/survey completion, participants can mature and change, this can influence the outcome of the research	Researchers can select participants who change at the same time or limit time	A maximum of 30-day period was utilised to control the threat where any data collected after this period was discounted. A 30-day period was not significant as compared to the overall duration of both projects; 24 months and 36 months.
Selection	Participants can be selected with certain characteristics that inflict bias	The researcher can select participants randomly	The participants selected from the project were ones who engage in project level collaboration as suggested by the lead designer and the firm managing director. Data was collected from all participants available during the 30-day period, selection was done regardless of personal characteristics
Mortality (Study Attrition)	Participants dropping out	Recruit a large sample size	The participants were given a 12-month period to drop out of the study, this period has now been completed and therefore mortality is not a threat
Testing	Participants become familiar with the outcome measure, therefore inflicting bias with regards to showing that the project is more collaborative	Use different items on a later test or have a longer time interval between testing	Qualitative and quantitative data was triangulated to see whether there is similarity in the outcome, furthermore, some constructs in the quantitative tool were negated to avoid 'habitual' answers
Instrumentation	The instrument changes during the experiment	Researcher to use the same instruments	The same web-based questionnaire was used throughout the research process

Statistical data was collected from twenty-two participants from two project in the exploratory study, using a QI (see Appendix D).

The quantitative data was analysed using a software called the Statistical Package for the Social Sciences (SPSS) and an Independent *t* test was performed. The Independent *t* test is used to compare the means and standard deviations between the two sets of data collected from each project. In the statistical analysis, a two-tailed hypothesis was applied and a $p<.05$ level of significance used. The two-tailed hypothesis excludes extreme data points (more than 47.5% more or less than the mean), that can significantly alter the mean.

3.4 Analysis and Discussion

Collaboration is critical at the project level; every project involves collaboration. However, the literature remains uncertain on how to foster a positive collaborative environment in the context described by this research. From the qualitative and quantitative data collected, factors that affect collaboration were developed from the comparison of two projects' collaborative cultures. Existing literature highlights the importance of culture in exchanging information and reasoning for making decisions (Avruch, 1998; Kimmel, 2000). From the two projects studied, one interviewee involved in both projects confirmed that Project B had a more positive collaborative culture fostered by openness and flexibility as compared to Project A. This section describes the qualitative findings in relation to the quantitative findings. A higher level of complexity was found in qualitative data than expected. Although many factors emerged, it is important to emphasize that collaboration cannot be limited to these factors. However, the study in the Zambian context found these factors as the most critical, based on practitioners' experience and perception. The quantitative results are shown in detail in Appendix G. On a general note and in relation to the main study in this thesis, the qualitative data brought out the high interdependency between factors resulting in observable links between phenomena, even ones that were not part of the questions.

This section describes the phenomena that emerged from the comparison between the design teams in each construction project. Section 3.4.1 explains the similarities and contradictions between the projects. Sections 3.4.2 to 3.4.9 describe the main findings in relation to relevant literature. Section 3.4.10 describes a holistic view of data collected.

3.4.1 Similarities and Contradictions Between Cases

Table 6 summarises the contrasts between the cases.

Table 6: Contradictions Between Projects A and B

Contradiction	Project A	Project B
Stage with Major Team Involvement	Initial design	Concept
Tender Method	Cost	Cost, Quality and Previous Projects
Value of Project	$72 million	$21 million
Client Representation	1 Representative	Team of 7 Discipline Specific Representatives
Client type	Primary Client	Secondary Client
Procurement	Design & Build	Design – BID – Build
Fund Origin	Loan financed	Donor financed
Allocation of Project value towards design	4%	6%
Number of Teams in consortia serving client	4 teams/firms	5 teams/firms
Data Exchange/Sharing	None	Teams agreed to share 2D models/files and geometric coordination systems

The two cases studied also had a number of similarities:

(1) Both projects were led by the architect and only involved design firms from the Zambian AEC industry;

(2) The firms were invited to tender by advertisement in the local newspaper;

(3) In both projects, the level of digital technology used was of 2D CAD drawings to develop designs of mixed-use buildings;

(4) Both projects had public clients who were working with the consortia for the first time;

(5) The payment method was also similar as teams were paid based on a percentage of the total cost.

3.4.2 Motivation and Dedication of Teams

Table 6 shows the differences in terms of monetary value between the two projects: Project A had a significantly lower percentage of total value (4% vs. 6% of the total project budget) allocated to design teams than Project B. Although Kent & Becerik-Gerber (2010) concluded that monetary incentives are not the most efficient at fostering collaboration, interviewees mentioned this as a constraint to efficient project delivery and collaboration as they did not feel that the teams were allocated enough resources.

'We will sort it out on site' (Structural Engineer, Project A)

The attitude to solve the clashes in design when construction occurs was a common notion from teams. Therefore, showing a lack of dedication in Project A, which may be due to the low design fees as they had projects that were more profitable.

Unlike Project B, Project A conveyed a traditional blame-based culture as observed by the number of instances where interviewees placed blame on other teams. On the other hand, interviewees involved in Project B did not place any blame onto the other teams and appeared to be more cooperative.

3.4.3 Existing Relationships Between Teams

Kent & Becerik-Gerber (2010) explain the criticality of good working relationships to a collaborative environment. The relationships between the teams with respect to the collaborative culture was probed in the semi-structured interviews. Culture is a constantly developed and changing group construct which depends on the interacting individuals (Lulofs and Cahn, 2000). The 'interacting individuals' suggest that the relationships between teams is an important factor in fostering collaboration. Figure 21 shows that Project B involved teams that worked together in a collective manner on numerous occasions bringing about strong existing relationships which affected one another's organisational cultures creating a form of unity in human interaction at the project level. Teams on Project B also developed relationships during the scope of the project, where the lead architect required input and visited similar projects in nearby countries. A number of interviewees agreed that this initial investment of time made developing the collaborative culture easier.

Project A teams had some history in working together which brought about a mix of relationship strengths between the teams; suggesting a constraint in fostering project level collaboration. Furthermore, Fulford & Standing (2014) explain that efficiency is affected by 'distributed project teams' which produce non-aligned processes. The two cases studied suggest a correlation that longer existing relationships provide a more aligned work process therefore, fostering a positive collaborative culture.

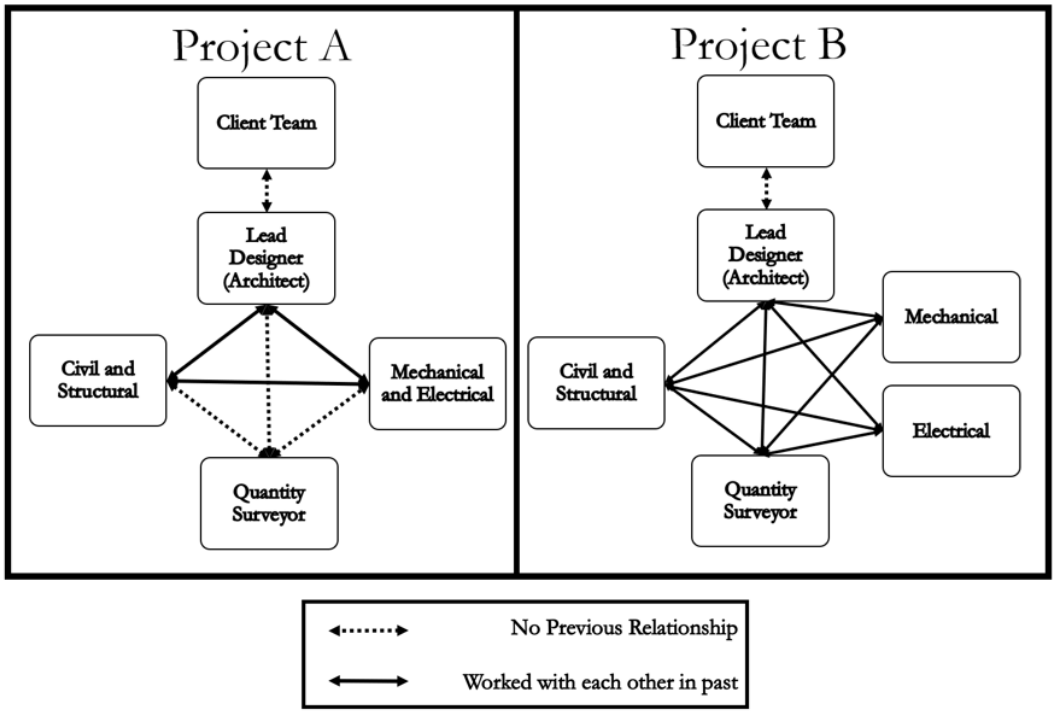


Figure 21: Structure and Relationships Between Teams

3.4.4 Leadership

Good leadership is required to encourage a collaborative team environment (Kent and Becerik-Gerber, 2010). Naismith *et al.*, (2016) explain the common belief that power can shape conflict or resolve it. Project A was run by shaping conflict as the lead designer was the centre of heated project meetings. Project B was run by trying to avoid conflict in order to resolve it by developing openness between teams.

The leadership style employed in Project A was highly diplomatic and centralised where the lead designer would be involved in all communication between teams. The lead designer of Project B approached managing teams in a decentralised manner by allowing a high level of flexibility and would only get involved when necessary, this may partially be due to the long existing relationships between the teams. This allowed for responsibility to be divided by the teams in Project B; further justified by the quantitative data. The level of agreeance of 'I feel that the project has a clear and defined leader' (T1 – representing a construct from teamwork see Appendix G) showed a slightly higher level of agreement in Project A that reiterates that the lead designer in Project A was the clear leader whereas on Project B the lower agreement may be due to a culture of teams leading one another. Furthermore, agreeance with 'It is important that the lead designer arranges work in ways that helps each disciplinary group reach their goals' (T2) showed that the way the lead designer sets up communication and information exchange was more important to Project B than to Project A participants. Correlations from agreeance of 'I feel that I am not able to make significant decisions without consulting the lead designer' (T17) also

show that Project B members felt that they were able to make significant decisions without consulting the lead designer; therefore, given more freedom.

Bronstein (2003: p. 299) explains the need for 'the collective ownership of goals' due to the shared responsibility in making decisions in delivering a product/project for one client. Project B involved teams that lead one another unlike Project A where the lead designer was the only leader; showing higher collective ownership of goals in Project B.

3.4.5 Agreeableness and Collective Understanding

A holistic analysis of personal characteristics was conducted using the statistical average values for each project. Only the collective agreeableness (mean of all project participants agreeableness) trait was statistically valid. From a holistic analysis of the personalities involved in projects, it was found that Project B had a statistically significant higher value of collective agreeableness (σ 2-tailed= .018, $p < .05$) than Project A. This outcome supports the idea that participants in Project B are generally more sympathetic to others and eager to help. From the literature, Hodges (2002) claims that a higher degree of agreeableness tends to avoid conflicts and therefore could be considered a relevant factor in the context of this thesis.

Bronstein (2003: p. 299) explains the need to work interdependently in collaborative environments which requires collective understanding between the teams. Both qualitative and quantitative data showed a higher level of collective understanding in Project B which may have been developed by the leadership style and long history of working. The agreement with 'professionals from other disciplines are bad at exchanging information with each other about how they work' (T12) showed a significantly lower level of agreement in Project B (σ 2-tailed= .037, p-value<.05), which further shows that the teams value understanding how others work more than in Project A. Furthermore, when respondents were asked if they felt that the lead designer should arrange work in ways to help each group, Project B showed a greater level of agreement.

The better common understanding presented by Project B was also shown by the higher agreement as they felt that they could 'rely on the other teams for help and support' (T13).

3.4.6 Variance in Level of Digital Technology Between Teams

From the levels of digital technology defined by Eastman *et al.*, (2011), the Zambian industry operates between level 0 (uncoordinated 2D documents) and Level 1 (coordinated 2D documents and models). When project level participants were asked what level of digital technology was used, a higher variance of responses came from Project A as compared to Project B. Teams involved in Project B were able to output information the way other teams required, however Project A participants exchanged information via the leader only. Some of the teams in Project A required paper-based information unlike others that preferred digital files. Project A involved no formal method to coordinate information whereas Project B developed coordinate systems and grids to ensure all the geometric information could be easily layered.

3.4.7 Formal and Informal Communication

The Project A lead designer was involved in all communication between teams by emails where he would be copied in. Whereas in Project B, teams would only involve the lead designer when needed. Furthermore, in Project B the personal relationship between the teams allowed for a significant amount of informal communication due to the collective working history of the teams.

In both projects, weekly meetings were a common form of formal communication however, interviews made it clear that the nature of meetings differed; in Project A the meetings were a lot more argumentative than in Project B.

From the quantitative data, the higher average perception of 'good communication between the teams' (T11) in Project B confirms that Project B had better communication than Project A. Further reiterated by the statistically significant T12 also showing this trend.

Raab *et al.*, (2009) explain that organisations do not just follow the formal methods of coordinating and communicating, but they also have informal methods. Formal methods are those that are recorded, and informal are vice versa (Dainty et al., 2007). From the qualitative data, Project A had a greater amount of formal coordination where all information would be passed through the lead designer. Whereas, Project B involved more informal coordinating/communication as the teams would only involve the lead designer if necessary. The facilitation of increased informal coordinating in this context may be due to the stronger relationships between teams in Project B due to the history and early high involvement in the project. Like mechanisms of coordination and communication, collaboration can be categorised as informal and formal. For example, in this context, Project B was more collaborative than Project A partly because of the way informal information was flowing between teams, which was a stronger effect than the formal nature put forth by the increased fragmentation as shown in Figure 21. Furthermore, from the qualitative data, we can see that the interviewees felt more integrated with other teams in Project B. The authors believe that this was further reiterated by the holistic analysis of the quantitative data where less variance in perception of digital technology, teamwork environment and systemic risk showed a less unified perception in Project A than Project B.

3.4.8 Client Knowledge and Involvement

According to de Blois *et al.*, (2011), primary clients are those that would lease, sell, invest in buildings whereas secondary clients build to operate in the building. Project A had a primary client whereas Project B had a secondary client.

As shown in Table 6, Project A had one client representative, whereas Project B had a team consisting of 7 members. Project B had a representative for each discipline and therefore helped make discipline specific client requirements whereas Project A had one project manager who would leave it to the consortia of designers to decide. When the lead designer was asked why the client was involved at a low level, it was clear that the Fédération Internationale Des

Ingénieurs-Conseils (FIDIC) contract used between client and consortia was a loan requirement and the interviewee's view was that the contract involves low client involvement to reduce the risk of corruption in a developing country. Other interviewees claimed that in Project A there was a lack of client output and when there was, the output would be delayed; forcing teams to make more assumptions driving more uncertainty into the design solutions.

On the other hand, Project B had a client's team that involved an architect, civil and structural engineers, electrical engineers, mechanical engineers and a project manager who would collectively scrutinize decisions made by the design team at periodic moments of the project. The client team's aim was to ensure that the design was within the client requirements. They were also easily accessible to the design teams as they were delegated to their respective discipline via the lead designer.

Further strengthening the client team in Project B was the involvement of building end users who made specific changes as early as possible; reducing the uncertainty of design requirements. The client representation in Project B was clearly more knowledgeable in construction practice than in Project A which reduced the number of client driven changes which allowed for a more positive collaborative effort.

3.4.9 First Involvement of Teams

A key difference between the projects' procurement was when the teams got involved. In Project A, teams were selected by the lead designer in the initial design stage, however in Project B the concept was designed carefully considering the views of the other design firms. Teams in Project B had the opportunity to visit similar projects together and openly voice concerns of the concepts presented by the architect with respect to their discipline related experience. Unlike Project B, interviewees from Project A commonly explained that teams felt that goals were independent to one another therefore only the work required was done unlike in Project B where it was easier to raise awareness of a problem that they see coming. From the interviews, Project A has a higher number of changes during the design phase than Project B. Views from the interviewees suggest that if the participants of Project A had been involved earlier, the number of changes would decrease. This suggests that the discipline related experience is critical in developing a more successful concept which would therefore reduce the number of changes during the design phase, and thereby increase the efficiency of team working.

3.4.10 Holistic Analysis

Franz *et al.*, (2017) concluded that more integrated and cohesive teams lead to better cost, schedule and quality outcomes. The qualitative data clearly justifies that Project B is more efficient in its delivery of output due to the more positive collaborative environment that was engendered by numeral factors, some of which have been discussed earlier. Furthermore, from the respondent/interviewee who participated in both projects it was clear that Project B was more efficient than Project A, although the culture of the teams was not of her preference. For example:

'If we gave the drawings from Project A to the contractor without being involved, it would make no sense to them, they would rather start the design again. However, in Project B, everything is well coordinated and can be constructed without significant changes or input from the design teams' (Electrical Engineer, Project A and Project B)

Fulford & Standing (2014) explain the need to view organisations in a holistic manner in order to improve the productivity in the AEC industry. The quantitative approach was used to assess the alignment of people's way of thinking in a project team. Furthermore, such holistic methodologies have been used in several similar industries such as health care where inefficient collaboration could lead to patient fatality. However, a key difference is in the number of respondents, reliability of quantitative data depends on the statistical validity; to counteract this limitation, qualitative data was introduced.

From the teamwork part of the quantitative data, there was less variance (as illustrated by standard deviation) in 78% of the data collected from Project B despite a higher fragmented project team and two more respondents. Therefore, in answering RQ1 – the variance in perception of the teamwork environment is related to positive collaborative culture efficiency. As the quantitative variance can only be verified by using qualitative study due to low statistical validity, a standalone quantitative tool requires further development. The constructs need further development within the construction management domain, further discussed in Section 3.5.

Similarly, from the systemic risk section of the quantitative data, 80% of the impact constructs provided a higher standard deviation in Project A. This supports the hypothesis that the project that has less variance in perception of systemic risk would be more efficient at collaborating. The results suggest a correlation between perception of systemic risk and alignment of perception and therefore indicate that the alignment in perception is symptomatic of how efficient a team can be collaborating.

Project B was more fragmented (with one additional firm) and had more respondents; both of which could bring in more variance to numerical data. Despite the increased probability for higher variance in Project B, the variance in perception of systemic risks and teamwork environment was lower in 80% of the constructs. Therefore, generally, the variances in data between the projects aligned with the views from the qualitative data; Project B has a more positive collaborative culture than Project A.

3.5 Limitations

On the question of the method, inevitably, the design used in this exploratory study cannot reflect the full range of variables present in the studied context. Nevertheless, it could be argued that ecological validity was enhanced by using actual design teams. The data would lack validation if quantitative data were analysed independently as it would lack statistical validity; teams typically appoint one or two experienced members to interact with other teams. This conservative management approach reduces the risk of liability by increasing control of exchanges with other teams. However, to develop a metric, further understanding of collaborative environments in

AEC projects would be most ideally done by collecting semi-structured qualitative data. With respect to the Cynefin framework this would mean; studying the complexity of project level collaboration to determine the interactions between phenomena by using a holistic perspective. Furthermore, it is suggested to conduct research in various countries' AEC industries to strengthen the generalisability of concepts and understand the role of local culture. Methodologically, the topic of collaboration can be studied in multiple ways. Unlike the project vs project perspective presented here, there needs to be other approaches to externally validate findings (Abowitz and Toole, 2009); studying collaboration using a one firm project management or an industry wide perspective can be useful.

The use of data collected from participant perception and expression of opinion had risk to being ethically insensitive, therefore, requiring ethics approval from the University of Liverpool and ERES converge in Zambia. This took nearly six months to achieve. Although the use of the approved consent form helped reassure anonymity and careful use which made most participants open about sensitive views on other teams or businesses.

Another limitation to the exploratory study was the limited time for data collection in Zambia. This impacted the method by making the study a convergent parallel mixed method. Should this study be repeated, it would be useful to conduct multiple stages to improve the precision of the constructs in the metric.

3.6 Conclusions

Two design teams from two construction projects in Zambia were compared. Both the qualitative and quantitative data showed that Project B was more positively collaborative than Project A. From the quantitative data, there was a higher variance in data collected from Project A than Project B. This suggests that the alignment of perspective was more in Project B. The limited number of participants involved in interactions and exchange between teams; a more precisely constructed metric is required. To answer SRQ1; it is possible to measure project level collaboration, however, the design of the QI needs to be very precise. This means that the interacting phenomena that represent project collaboration needs to be better understood. This was exemplified from the rich accounts from the qualitative data collected. The researcher's experience in collecting both quantitative and qualitative data facilitated a deeper understanding of both methods.

Findings of the exploratory study suggest that projects with more changes, more assumptions and uncertainty in requirements affect the collaborative nature of the project as they affect participant behaviours negatively; the more changes mean increased use of resources which are not always covered in the payment. Developing existing relationships between teams by early involvement and relationship building methods affect collaborative culture positively because people tend to have more shared understanding of one another's expectations and beliefs. Furthermore, history and experience of working with one another was found to align work

methods and mentality, reducing the potential for conflict, increasing common understanding and thereby encouraging a positive collaborative culture. The role of client knowledge and involvement reduced the uncertainty driven by client requirements, which helped avoid a negative collaborative culture. From the projects studied, it was also found that a decentralised leadership style negatively affects developing a positive collaborative culture. Monetary value added to a firm was linked to motivation and allocation of resources and showed as critical in ensuring collective ownership of goals.

The study of personality showed that the project with a positive collaborative culture had a statistically higher level of collective agreeableness. This means that the personality of individuals that represent firms in collaborative environments is more likely to be positive if there are more agreeable personalities.

For the progress of the research project, it should be noted that even though reductionist traits were used to design the quantitative parts. It was evident from the qualitative data that the topic was best suited to an interpretive approach owing to the complexity and interdependence of phenomena; questions and concepts are intertwined. This determined the development of SRQ2 and a change in methodology for the main study described in detail in Chapter 4.

4. METHODOLOGY

4.1 Introduction

The chapter describes the methodology used to answer the research questions (Table 1). The objective of this chapter is to outline a methodology which enables understanding of project level collaboration holistically, incorporating technical, process and human factors (SRQ2). Section 4.2 explains the philosophical stance taken by this research. Section 4.3 describes an overview of the commonly used research approaches in the Construction Management domain. Next, an application of the CIFE Horseshoe Framework (Kunz and Fischer, 2008) developed by the Centre for Integrated Facility Engineering (CIFE) of Stanford University is described in Section 4.5. The research framework was used to define the logic in structure of this chapter. Section 4.6 describes the role of existing knowledge and its use in the research. The way data was collected and analysed is outlined in Sections 4.7 and 4.8. The way that the analysis and findings were validated is explained in Section 4.8. Finally, Section 4.9 provides an overview of research approaches in connection to the sub-research questions in Table 1.

4.2 The Philosophical Stance

The philosophical stance taken by the research in this thesis is best described by critical realism. Bhaskar (1998, 2013) formulated critical realism; it is an alternative to interpretive and positivist philosophies, consisting of elements from both to provide researchers with new ways of describing the way knowledge is developed (Wynn and Williams, 2012). In other words, it combines a general philosophy of science with a philosophy of social science to describe an interface between the natural and social worlds. Essentially, critical realists believe that 'what is real' is not reducible to our knowledge of reality (Fletcher, 2017). The role of the researcher is to construct a narrative rather than discovering the truth (Cruickshank, 2003).

Critical realism is seen as a middle way between positivism and interpretivism (Zachariadis et al., 2010); of particular interest in information system research due to the interactions between technology (natural science) and people (applications in human contexts) (Zachariadis et al., 2010). The inference being that the way humans think and interact socially is to be considered when implementing systemic technological change. Regarding the fundamental assumption guiding the data collection and analysis, critical realism acknowledges an objective existence of reality from which research presents a subjective view of this reality (Kozhevnikov and Vincent, 2018).

In this predominantly qualitative research, there are both deductive and inductive processes (Creswell and Creswell, 2018). Deduction moves from general to specific and induction moves from specific to general. This research involves both. The deductive processes are in the way phenomena emerged in the main study's data collection. The practitioner's experience in project level collaboration was used to specify the factors that affect collaboration. The inductive

process involved using the deduced factors to create a general model based on assumptions to structure that model and represent the understanding gathered.

However, critical realism to the author's knowledge fits it best because critical realism allows the combination of interpretivism and some reductionism. In essence, it is impractical to claim that this research is purely interpretivist because, e.g., the induction of the model using assumptions of structure and hierarchy. The structure and hierarchy used in this thesis is that of the external analysis model applied in many organisational studies (e.g., Moum, 2008); micro, meso and macro all represent a perspective of the industry (see Figure 3). It is also impractical to claim that this research does not have interpretivist traits as both participants and researcher were interpreting experiences to understand the social reality of collaborative practice. Therefore, it is a blend of both interpreting reality by reconsidering previous hypotheses and developing an understanding of reality by making suitable assumptions.

The more subjective nature of the research comes from its interpretivist traits; Deetz (1996) explains that in pure organisation science the interpretive approach is one that is subjective as there is a need for the researcher's own frame of reference to interpret artefacts and apply semantics. This is the reason for utilising external analysis models as a point of departure, building on existing interpretations of reality.

The data collection method most suitable to the context was therefore qualitative methods which were adopted as the main source of data collection. This approach allowed for richness of data in factors studied, giving the researcher a prime perspective of the interaction between phenomena.

In order to develop better holistic understanding of collaboration from various perspectives, an interpretive approach is considered most suitable. Furthermore, from a semantic point of view, definitions of the factors are treated with importance, therefore, a glossary of terms is provided in Appendix A; the definition of concepts and terminology reflects the reductionist traits as these definitions represent assumption of meaning.

4.3 Approaches to Data Collection in Research

In management related literature, Easterby-Smith, Thorpe & Lowe (1991) defines research as a systematic process of enquiry and examination using valid methods which can lead to discovery of unknown relationships and create new knowledge. Research approaches vary between sciences in different ways depending on the research philosophy, which can vary between the ontological, epistemological and axiological philosophy. A research approach governed by the philosophy defines the manner in which data is collected, analysed, interpreted and concluded (Howell, 2015).

In the field of construction management, research is not purely technical as in engineering; it often involves knowledge from various disciplines e.g., engineering, technology, management, social science, and psychology. Therefore, research in this multi-disciplinary area involves exploration of fundamental theories from various disciplines to gather deeper

understanding. A robust design of the research method to investigate research questions and meet objectives is a requirement to ensure findings are valid.

Three types of research commonly used today, that best suit this area of research are (Fellows and Liu, 2015; Creswell and Creswell, 2018); 1) qualitative (see Section 4.3.1), 2) quantitative (see Section 4.3.2) and 3) mixed methods (see Section 4.3.3).

4.3.1 Qualitative Research

Originating in the social science field and known to be a 'soft' method, qualitative research has become a widely used method to understand social phenomena and human problems (Fellows and Liu, 2015). Qualitative research is interpretive (Denzin & Lincoln, 1994: p .2) inductive and heterogeneous (Maxwell, 2004: p. 36). Qualitative research can also be defined by methodology that gathers subjective data to form the basis for analysis and further understanding (Kimmance, 2002). The process involves guidelines to reasoning rather than rules.

The process of qualitative research is more subjective as data is collected and analysed based on the perception of the researcher. Data collection is achieved using open questions and analysed to find the meaning of data by searching for general rules and emergent themes (Creswell and Creswell, 2018). In simple terms, qualitative research is used to develop understanding of phenomena by carefully collecting a rich collection of data by developing robust design guidelines.

Literature also reiterates qualitative research as being most suitable to 'discover the new' (Flick, 2014: p. 5) and to associate them with existing knowledge; therefore making it the most suitable option to study collaboration.

In the context of the main study, semi-structured interviews/focus groups about a central theme are utilised. Qualitative research interviews are used to describe and develop the meaning of central themes in the world of the participants (Flinders, 1997). Focus groups were also used for part of the data collection; Breen (2006) describes this as a qualitative method for researchers to generate ideas by moderating discussion between a group of ideally 4 to 6 participants. Breen (2006) also suggests that a sample size of 10 to 12 participants are ideal for ensuring theoretical saturation for either focus groups or interviews.

4.3.2 Quantitative Research

As suggested by the name, quantitative research is the numerical representation of analysis to describe and explain phenomena (Caldas, 2003). The purpose of quantitative research is to discover differences and/or underlying relationships by examining and analysing variables which are based on objective based theories (Creswell and Creswell, 2018). Kimmance (2002) explains that the origin of quantitative methods is in natural sciences to study natural phenomena. Positivism based approaches underpin this research tradition as complexity is tackled by reductionism which emphasises objectivity, measurability and repeatability of variables (Locke et al., 2009). The critical part of the quantitative distinction is that the researcher should remain independent and maintain distance from the participants, and independently observe data. Unlike

qualitative research where acceptance or rejection of data driven claims can be argued but not certainly claimed, quantitative research allows researchers to distinctly reject or accept data (Kimmance, 2002). Although, with more certainty comes lower richness of data when compared to qualitative data. Keeping in mind that there are also uncertainties in statistical procedures and analysis.

In the main study, quantitative methods were excluded because of the conclusion of the exploratory study. It was deemed ineffective to grasp the complexity of phenomena associated with project level collaboration when compared to qualitative methods. This is not to say that quantitative methods cannot be used, but at the current state of knowledge (see Section 2.7.4), it would not be the best option.

4.3.3 Mixed Methods Research

Mixed methods involves the use of both qualitative and quantitative methods to develop understanding and gather statistical validity (Creswell and Creswell, 2018). Described as the integration of quantitative and qualitative research (Bryman, 2006), mixed methods is an approach that has characteristics of both quantitative and qualitative data. It is used to integrate data from various sources and follows a well-designed theoretical framework to examine complex phenomena (Creswell and Creswell, 2018). The purpose of this method is to combine both research approaches in order to provide a more accurate and complete understanding of a complex problem.

Advantages of mixed methods are that the qualitative approach brings richness of data and deep understanding whereas quantitative allows for greater statistical validity. There are three basic forms of mixed methods (Creswell and Creswell, 2018):

1) convergent parallel mixed methods: qualitative and quantitative data collected and analysed separately (at the same time) to seek (dis)confirmation,
2) explanatory sequential: quantitative data collected and analysed first to inform the design of the following qualitative phase,
3) exploratory sequential mixed methods: qualitative data collected and analysed first to inform the design of the following quantitative phase.

The convergent parallel mixed methods was found to be most suitable to the method adopted in the exploratory study; the convergence between qualitative data and quantitative data strengthened the findings. Furthermore, using mixed methods gave the researcher an understanding for both approaches in studying collaborative practice.

4.4 Guiding Research Framework Adopted

Research in Construction Management (CM) related to collaboration and digitalisation is interdisciplinary in nature. It is important to keep in mind the nature of the product of the AEC industry where every project is uniquely delivered. AEC projects involve complex processes comprising of technical engineering knowledge, experience-based decision-making, artistic

design, business management etc. Research in CM is different in nature to reductionist-based subjects that deal with a single aspect, where the problem can be clearly defined and described. Therefore, a research framework was used to guide the research process.

Applied to problem understanding, it should be noted that the 'CIFE Horseshoe Framework' (Kunz and Fischer, 2008) developed by the Centre for Integrated Facility Engineering (CIFE) of Stanford University, shown in Figure 22, is a simplified view of the research process where processes are represented in a linear manner. It is a highly iterative process that starts from developing a better understanding of the observed problem which changes throughout the research process. The framework has a reflective approach; the later part of the framework must be developed with respect to the beginning as shown by the dotted line in Figure 22; e.g.,, the claimed contributions can only be developed if there is a clear understanding of the existing knowledge that the Point of Departure (POD) brings forth.

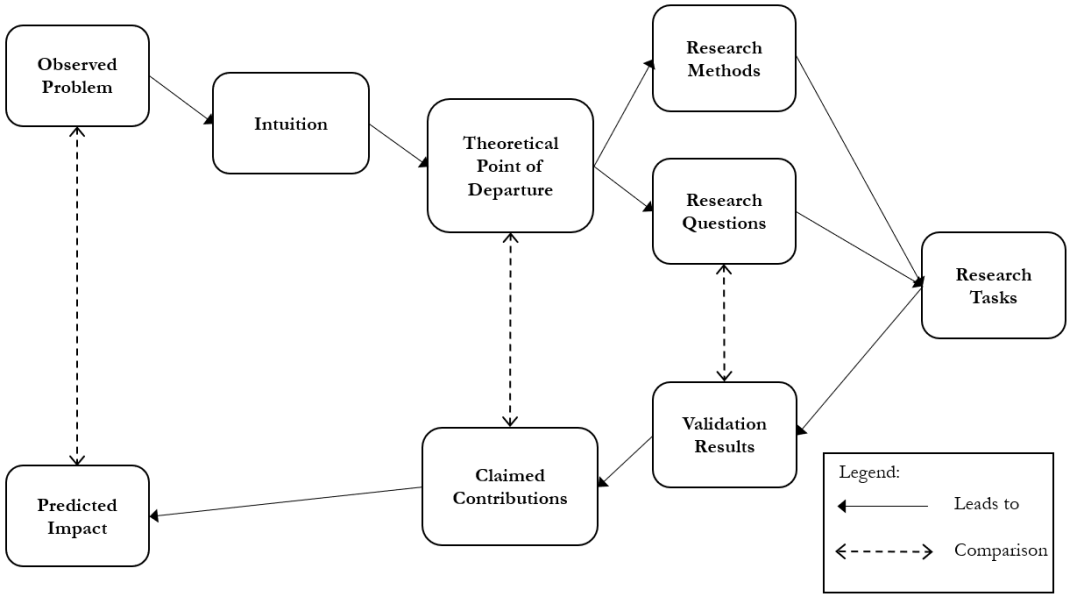


Figure 22: Overview of the 'CIFE Horseshoe Framework' (Kunz and Fischer, 2008) **developed by the Centre for Integrated Facility Engineering (CIFE) of Stanford University**

To ensure the aims and objectives described in Chapter 1 are relevant and well addressed, the CIFE Horseshoe Framework (Kunz and Fischer, 2008) was selected (see Figure 22). It describes a structured plan to manage applied theoretical research in the AEC industry. The starting point of the framework is in observing a real-world problem. In this research, the real-world problem addressed was discovered when conducting the exploratory study (see Chapter 3) and the research gaps (Section 2.7.4). Understanding the complexity of collaborative practice from reality was deemed necessary. Furthermore, in Chapter 2 it is observed that the implementation and success of BIM has not been as successful as scholars and practitioners expected. When barriers of its implementation were studied several of the outcomes relate to people and their ability to collaborate using processes. From these observations, the researcher proposed to find a way to

address the problem or understand it better. The intuition to the observed problem is that there is a lack of understanding in how people interoperate in the AEC industry. Followed by the researcher's intuition, the theoretical POD is developed based on existing knowledge found in literature. Subsequently, the researcher applies theories or approaches that exist as a starting point to the development of the research method. The theoretical perspectives used are shown in Table 7.

Table 7: Theoretical Points of Departure

Point of Departure	Discipline/Area of knowledge	Section	Application
Structuration Theory	Sociology	2.6.2	The two theories are used together as an analytical starting point. CHAT allows the use of practitioner experience which reflects their historical and cultural perspective of practice. Structuration theory forms the basis of categorising the complex data collected.
Cultural Historical Activity Theory (CHAT)			
Theory of Planned Behaviour (TPB)	Psychology	2.6.1	The theory is used as a basis to search for decision-making dependency facilitating the connection between biases and beliefs.
Systems Thinking	Sociology	2.6.3	Systems thinking was utilised in the data collection and analysis process. In data collection, the unstructured format that involved discussion surrounding a central theme avoided oversimplification from the researcher's viewpoint.
Cynefin Framework	Complexity Science	1.3	The sense-making process describes the process of analysis by the researcher.
External Analysis Model	Applied in multiple disciplines	0, 2.2.3	Used to categorise the data collected with reference to widely used categories in literature.
Downes' Law	Business	2.2	Showing the need for social, political and business reform in supporting technological change.

The research methods need to be developed closely to the observed problem, point of departure and existing knowledge method in order to ensure that the method is the most suitable way to investigate the research questions. The selection of semi-structured interviews and focus groups to collect rich qualitative data was a decision determined from:

- Research gaps showing fragmented knowledge (see Section 2.7.4),
- The need to transfer knowledge from practice to academic domains (see Section 2.7.4),
- The researcher's experience in the exploratory study showing the qualitative data provided a more flexible and reliable account of the complexity of interacting phenomena in reality,
- The ability of the qualitative data to provide a rich account of reality (Creswell and Creswell, 2018).

Other scholars have taken similar approaches in studying topics with interacting phenomena like in this one. For example, Orgen *et al.*, (2015) studied the nature of collaboration between firms using in-depth interviews, Dewulf and Kadefors (2012) studied partnering schemes and trust in public construction also through the use of semi-structured interviews.

The research method then separated into tasks that involve data collection and analysis. An overview of the research tasks is shown in Figure 23 below; each task is described in the following sections of this chapter.

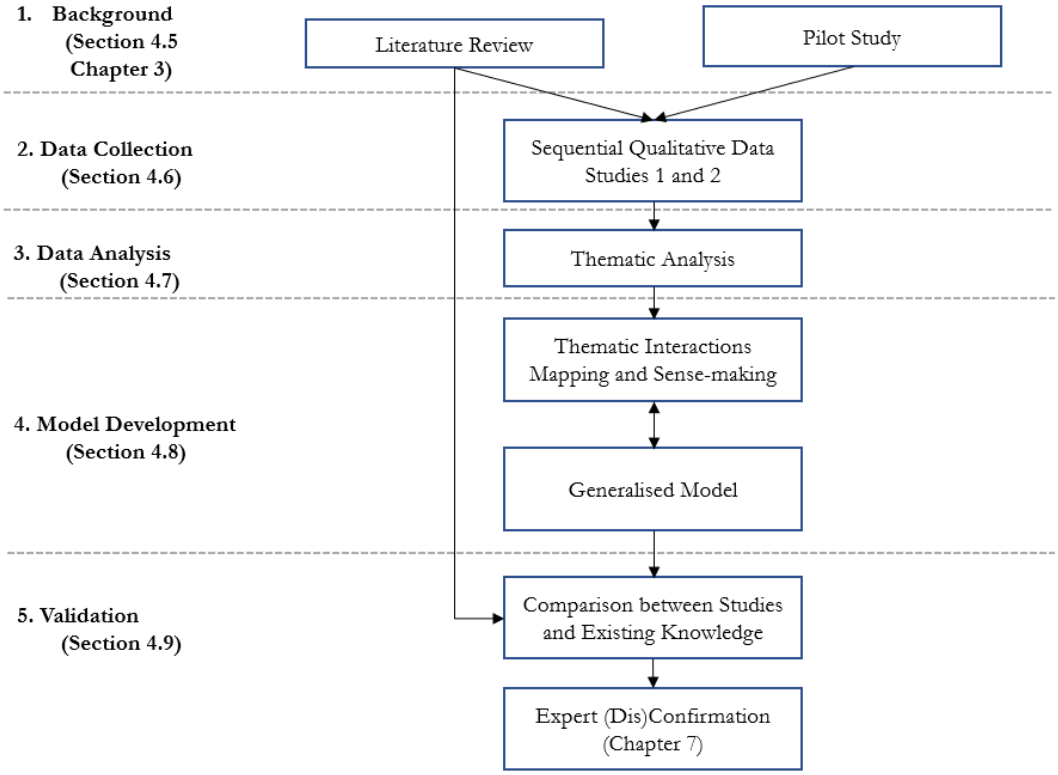


Figure 23: Overview of Research Tasks

Validation of findings with respect to research questions and the POD shows contributions towards or against existing knowledge or theories. The validation tasks are two-fold; they involved comparing the knowledge acquired to existing knowledge and used expert semi-structured interviews to locate gaps, inconsistencies and validate the observed problems and model developed.

Once the existing knowledge was built upon, the researcher was then able to make claims towards knowledge contributions and envisage the impact to give a decisive starting point for future research. It should be noted that this thesis focuses on problem understanding due to the complexity of the observed problem. By interpreting reality using qualitative data and inducing a model based on sense-making and holistic understanding; observed problems, combined knowledge, theoretical application are presented. The philosophical paradigm that suits this research is therefore critical realism because it allows for intertwined assumptions facilitating deductive and inductive tasks (see Section 4.2).

Although this section focuses on the research methods and tasks, it is important to show how and why the research method was adopted, which means that there is a need to build from the observed problem as shown in Figure 22. It is discussed in Chapter 2 that similar industries such as health care have made significant movements towards developing a holistic perspective in practitioner thinking e.g.„ the biopsychosocial approach (see Section 2.7.2). The literature review shows a range of factors that affect AEC collaboration; however, the knowledge gap arises when understanding how these various factors interact in such a complex environment. Existing knowledge tends to be highly detailed in specific parts of the understanding of collaboration but holistic understanding of interaction between factors is sparse; posing the question - how do the factors position themselves with respect to one another? This is the reason behind the focus of the theoretical POD involving Cynefin framework, systems thinking and social theories such as Structuration theory and CHAT. Combining multiple perspectives provides greater understanding that, in turn, reflects the complex reality of the subject matter.

4.5 Literature Review

A review of literature was undertaken to understand what existing knowledge exists about collaboration in the AEC industry. It should be noted that as described earlier in Section 4.4, the development of the researcher's intuition and observed problem was an iterative process, therefore the focus in the beginning was on BIM adoption. As barriers to BIM as shown in Figure 9 were developed, a number of barriers were to do with people collaborating rather than tools. Therefore, the focus of the literature review shifted into collaboration and the evolution of the keywords began to expand about the central topic of collaboration.

The quest in developing understanding from existing knowledge continued throughout the research process even after the observed problem and gaps were defined. This was driven by the exploratory nature of qualitative research as open-ended questions formed the guideline of the interviews and focus groups meaning that participants brought in relevant experience driven topics for discussion. As topics emerged from the data collected that were not seen as important at the beginning of the research process, these were treated as important in the final literature review found in Chapter 2. The complexity of the combination of literature reviewed reflects the high complexity of the topic facilitated by a flexible semi-structured data collection approach; this makes the exclusion/inclusion criteria of the literature review dependant on the data collected, analysed with the researcher's understanding which was also partially developed from literature. This means that to validate the claims made by the research conducted, the literature review had to be consistently adapted for example, from the results, themes such as 'client involvement', 'conflict resolution', 'personality', 'local policy' etc. had emerged, therefore shifting the scope of the literature review.

Literature that was purely technical (that does not include people oriented concepts) were excluded reflecting the data collected. Pure psychological/social science studies were excluded if

there was in-depth application in the CM domain. If not, concepts for further understanding were taken from psychology and social science e.g., understanding the process of decision-making.

4.6 Data Collection

An overview of studies is shown in Table 8. Qualitative data was collected from both studies. Therefore, this section explains the approach taken in Study 1 (see Section 4.6.1) and Study 2 (see Section 4.6.2). Each section explains the sampling technique utilised, how participants were informed, the timescale, the approach of the researcher together with an outline of the questions. Due to ethical requirements, the name of participants and firms are not disclosed (see Section 4.6.3).

The exploratory study presented in Chapter 3 gave the researcher experience and an opportunity to find the most appropriate method. From the exploratory study, it was found that there is need to further understand the complexity of project level collaboration best suited by qualitative data that utilises an unstructured style of questioning. This conclusion was reached as a result of the tendency of the exploratory project semi-structured interviews becoming unstructured due to the interdependence between phenomena. Additionally, probes were topics determined from the exploratory study including; client, leadership, relationships, motivation, contracts, procurement, first involvement and personality. Therefore, the exploratory study was vital in the methodological design of Studies 1 and 2.

Table 8: Overview of Studies

		Study	
Location		**Study 1: Finland**	**Study 2: Norway**
Approach		End to End, One Firm Perspective	End to End perspective, Multiple Firms
Duration		5 Days	5 Days
Method	**Focus Groups**	Nil	5 (16 participants)
	Individual Semi-Structured Interviews	18	Nil
	Surveys	Nil	
Analysis	**Quantitative**	Not applicable	
	Qualitative	Thematic Analysis	
Participant Classification		End to End Project Management (Design and Production Managers)	2 Contractors, 1 Project Management, 1 Public Client, 1 Consultant, 1 Industry Organisation

4.6.1 Study 1 Qualitative Data

The first study was conducted in Finland. Participants were recruited from a Project Management (PM) firm in Helsinki, who manage the design and production of AEC projects. The data was collected over a period of 5 days and a breakdown of the participants is shown in Table 9. The gatekeeper was an employee of the PM firm involved in its higher level management. The sampling strategy adopted was based on the convenience of the gatekeeper with the purpose of covering the end to end AEC process.

Table 9: Study 1 Participants

Role	Number of Participants	Description of Role
Site engineer	2	Works with the site manager on site in being the lead team on site. Assists in managing the sub-contractors and daily operations on site. Involved in motivating the sub-contractors and dealing with design changes. Partially involved in procurement of sub-contractors.
Service engineer	1	Pipe renovations from start to finish, design to production. Direct link to client and managing the designs and sub-contractors.
Site manager	4	The leader of production on site. Assisted by site engineers and holds a role to manage sub-contractors and resources used on site. Also involved in site originating design changes.
Design manager	3	The leader of the design teams; controls collaboration between design teams by the use of digital tools and big room discussions. Also involved in some circumstances in the procurement of design teams. Involved in 3 to 4 projects at the same time.
IT development	2	A strategic organisational role involving process management to ensure that projects follow the strategy of the firm. Developing the process of construction continuously.
Schedule Management	2	Managing the schedules of projects, at least 10 projects at a time. Developing a master schedule and then adding more detail as the process evolves.
Procurement	1	Selection and controlling sub-contractors. Development of sub-contractor contracts.
Development Manager	2	Manages developments that the firm partially have a stake in from beginning to end mainly in residential developments.
Research and Development	1	Involved in developing innovative ideas to improve productivity in the firm. Highly involved in developing an organisation wide learning system.
Total	18	

All participants were involved in individual semi-structured interviews. As in the exploratory study, the interview began with the participant information sheet and consent form as part of the ethical requirements explained in Section 4.6.3. The interview then began by asking the interviewee their role in the company and to give a short historical overview of their role. The

participants were asked to define collaboration in the simplest way possible to engage them in the thought of collaboration. Once defined, they were asked openly what they felt was the difficulty in collaboration. Once answered, the researcher probed the participant with reference to topics shown in the guide presented in Appendix E.

4.6.2 Study 2 Qualitative Data

Focus groups and individual interviews were conducted with 2 contractors, 1 client organisation, 1 design firm, 1 professional organisation and 1 project management firm in Norway. Information regarding the participants is provided in Table 10. The gatekeeper was an academic with a strong interest in the research and a wide network in the Norwegian AEC industry. Based on convenience, the gatekeeper arranged focus groups, keeping in mind the need to cover end to end perspectives. A focus group approach was selected because of the limited time of the data collection trip, simplified the arrangement process for the gatekeeper and provided a variation in collection strategy.

Table 10: Study 2 Participant Frequency and Company Information

Category of Firm	Number of Participants	Description of Firm and Participants
Contractor	2	Involved in building and civil projects. Primarily running projects in Norway and have begun to work in Sweden. Privately owned firm and approximately 65% of shares are owned by employees. Participants are innovation managers in the firm.
Contractor	3	Involved in civil and building construction in Norway. One of the largest contractors in Norway regarding building construction. Participants involved were involved in BIM driven innovation in teaching staff and developing process management.
Design and Management Firm	4	Primarily a design firm who has the ability to manage the end to end construction process. One of Norway's top 6 design firms. Participants involved was an innovation manager, project design manager and a Building Information Management Modelling (BIMM) coordinator/manager.
Public Client	2	A Norwegian government funded client who is involved in the development, management and facilities management of buildings. The participants were involved at the strategic level in developing the use of innovative technologies e.g., BIM and developing client requirements.
Professional Organisation	2	Participants were involved in the national development of standards and innovation development.
Project Management Firm	3	A firm that controls the end to end process of construction projects similar to Study 1 PM firm 2. The participants were involved in developing organisational strategies and innovations.

Total	16

The qualitative data collected in this study was directed by the researcher in a different approach to that applied in the exploratory study and Study 1. The approach of focus groups, as outlined by Breen (2006), is to facilitate dialogue and not control it as in semi-structured interviews. Therefore, focus groups were led by topics relating to the discussion as it progressed. The guide utilised by the researcher can be found in Appendix F.

The discussion began similarly to that in Studies 1 and 2; participant information sheet and consent form was used to introduce the study and acquire consent as per the ethical requirements of the University of Liverpool. Participants were asked to introduce themselves in terms of role in the firm, academic or technical background, and were asked for a brief overview of the operations of the firm. Participants were then engaged in a discussion to define collaboration, followed by a discussion of 'what the important factor in collaborating is'. Once the discussion developed, it tended to move from topic to topic where each participant presented their view in agreement to one another or in disagreement to one another. The researcher would then ask for more detail or any clarifications on the information provided by the participants. The researcher's role therefore was to facilitate dialogue by ensuring that each described factor was sufficiently probed and explained from the participants' perspective.

The focus group approach is one that generates ideas by moderating discussions unlike interviews which probe experience and involves direct questioning (Breen, 2006). In this study, the researcher envisaged a discussion of ideas pertaining to understand factors that lead to positive collaboration. Breen (2006) explains that groups of 4 to 6 participants in each focus group are ideal, although in this study, it varied from 2 to 4 participants and is discussed in the research's limitations. The researcher ensured the same moderating role to generate ideas even though there were a lower number of participants in some of the focus groups. Furthermore, the researcher consistently engaged all participants equally, if one participant was not getting involved, the researcher asked for their opinion. In other words, the role of the researcher was to facilitate discussion and engage all participants in discussions.

4.6.3 Ethical Considerations

As the research method collects information from people, it is a condition that ethical approvals were sought prior to the collection of data. Ethical approval was achieved from the Faculty of Science and Engineering ethics committee at the University of Liverpool (approval reference = 1614). As part of this approval, it was required to gather consent from the participant and provide them with information regarding the study. An example of the participant information sheet and consent form is attached in Appendix B.

Local approval is also a requirement for all studies if required by the local authorities. For the exploratory study this is described in Section 3.3. Studies 1 and 2 did not require formal

ethical approvals from local institutions as the topic of the research project did not fall into categories that require ethical approval. However, information to guide the researcher was available in Norway (see https://www.etikkom.no/en/).

4.7 Qualitative Data Analysis

Data collected was transcribed manually using voice recordings. Once transcribed, thematic analysis was conducted as described in Section 4.7.1. Thematic analysis was the primary method of sorting and collating qualitative data across all studies. To develop a holistic model, interactions between the themes were developed using the sense-making process and as the researcher's understanding evolved, the structure of the model was developed. This sense-making process is described in Section 4.7.2.

4.7.1 Thematic Analysis

Thematic analysis is a method to identify, analyse and report patterns within qualitative data (Braun and Clarke, 2006). The patterns are developed by defining themes which organise and describe the dataset which in turn maintains rich detail. Thematic analysis is explained in six steps however, it should be noted that the process is iterative as it requires checking whether defined codes and themes work with the data consistently throughout the process. The process of checking codes involved checking whether coded statements still fit within the definition of the theme. The six stages of thematic analysis (Braun and Clarke, 2006) are:

1. ***Familiarisation with the data***: the researcher must immerse themselves in and become familiar with the data. This process involves repeatedly reading the data and listening to audio recordings. The process is important to give the researcher an overall understanding of data collected.
2. ***Coding***: involves generating 'pithy' labels for important features of the data with respect to the research question guiding the analysis. In this context coding was undertaken with respect to the first research question – what affects collaboration at the project level? Therefore, any data seen to be representative of affecting collaboration was highlighted and labelled. It is important to note that coding is not only a process of data reduction but is also an analytical process. To be done most effectively, codes must reflect both a semantic and conceptual label of data. At the end of this phase codes and data extracts are collated.
3. ***Searching of themes within codes***: A theme is defined as a coherent and meaningful pattern in relation to a research question. Codes can be the thought of as the building blocks of the themes found. Codes related to one another are categorised under a theme. The process of searching for patterns between codes is an active process to ensure that no themes are hidden in the data. The themes are constructed from the codes and widened in scope until all codes are within a theme.

4. ***Review of themes***: involves a process of checking whether the themes are genuinely representing the data analysed. This process was not done immediately after the first three steps but was done with a relatively fresh outlook towards the data. It was also necessary to read some parts of the transcribed data once again while reviewing the themes to ensure that the themes best represent the data. It was required to restructure some themes and codes to best suit the data collected. Steps 2 and 3 are repeated if necessary.
5. ***Definition of themes***: once thematic and code structures are defined, themes require definition. The researcher asks how the theme aligns to answering the research question and what the theme tells about the codes under it; identifies the essence of each theme and constructs a concise and informative name.
6. ***Writing up***: involves weaving together the analytic narrative which consists of the themes and codes and important parts of the data extracts to present the argument to the reader in a coherent and persuasive manner. This is done with respect to existing literature to give the argument validation from existing knowledge.

The coding process in this thesis was carried out using Nvivo (QRSinternational, 2018). Nvivo is a useful tool in structuring the data and presented the researcher with data extracts under various themes and codes which were utilised at Steps 5 and 6.

4.7.2 Data Sense-making

Sense-making is described as the process by which individuals interpret and reinterpret events and put them into context of what is happening (Weick, 1993). The process happens both consciously and subconsciously. Subconsciously, this happens instantaneously enabling the researcher to deal with equivocal situations and contexts (Craig-Lees, 2001), recognised as feelings of surprise in hindsight (Pezzo, 2003). The sense-making process occur not only after data collection but also during it. The Cynefin framework (see Section 1.3) shows the importance of sense-making when developing understanding of complex topics, understanding was part of the researcher's role in interviews; the probe, sense, act was used in data collection. The probes were either a topic or requesting further explanation.

Visual representation of data is said to organise, summarise, simplify or transform data (Verdinelli and Scagnoli, 2013). Verdinelli and Scagnoli (2013) studied the use of visual representations or displays and present nine different types; boxed display, decision tree modelling, flowchart, ladder, matrix, metaphorical visual display, modified Venn diagram, network or taxonomy. The network was best suited as applied in this research and is used to depict relationships between themes or subthemes.

Thematic mapping of interactions was done manually with the use of EdrawMax software, based on output generated from the Nvivo file exported into Excel, it was possible to estimate the strength of links between themes. This was based on the frequency of emergence of

the link. The visual representation was developed with nodes and links. Each node represented a theme and a link represented a relationship between nodes. The link could either be two way or one way depending on the relationship between themes. The size of the node linearly increases depending on the number of links running to and from the node. The distance between nodes is not representative of any parameter. The value of thematic maps is not mainly in the frequency of themes and links but as a sense-making tool.

With the help of the thematic maps, narratives of the data were developed centred amongst the dominant themes. The data was split between project management centred and human factor centred narratives. Once narratives were complete, the narratives and data were thoroughly studied by the researcher to check the suitability of existing models, from which an adapted version of Van Notten's external analysis model was ideal (Van Notten et al., 2003).

Once the model's suitability was checked by cross checking the themes and narratives, the model was then used to make summary diagrams as shown in Chapter 5. Development of these summative diagrams can also be thought of as part of the process of checking the model suitability.

Furthermore, as in Chapter 6, literature was linked to the data used to develop the model and the model's conditions presented.

4.8 Validation and Reliability Process in Qualitative Research

Validity questions the authenticity of findings; whether the data represents reality or is trustworthy, authentic, and credible enough (Denzin & Lincoln, 2011: p. 120). Furthermore, reliability is explained to be an indication as to whether the researcher's approach is consistent across different researchers among different projects (Gibbs, 2007). The data collection method was designed taking into account researcher bias brought to qualitative data collection.

From the critical realist epistemological position, validation is debatable. Validity emerges as dominant in positivist approaches, whereas the model in this research is developed from interpreting qualitative data., which some would argue is more subjective than other approaches Therefore, quantitatively evaluating the internal/external validity, reliability and objectivity would be unsuitable to the methods implemented in this research. From a critical realist point of view, determining variances in data cannot be justified to indicate the presence of flaws (Bhaskar, 1998; Creswell and Miller, 2000; Smith and Johnston, 2014). However, there are ways to enhance validity in more subjective data interpretation and analysis (Maxwell, 2012). Evaluation of the model's framework through the lens of a critical realist must recognize that variance in data cannot be avoided as individuals interpret reality differently according to their experiences, personal characteristics, and so on, forming a varied set of environments.

Validity is said to be one of the strengths of qualitative research if the researcher's interpretation accurately describes the participant's intended meaning (Creswell and Miller, 2000).

The terms that validity is described by are trustworthiness, authenticity and credibility (Creswell and Miller, 2000).

Table 11 shows a summary of the validity procedures of a critical realist approach. Creswell & Miller (2000) explains the use of collaboration in the research design to allow internal validation. Collaboration in the context of validity, means:

> 'the participants are involved in the study as either co-researchers or in less formal arrangements' (Creswell & Miller, 2000: p. 128)

Table 11: Summary of Research Paradigm and Validity Procedures (Adapted from Creswell & Miller, 2000)

		Research Paradigm		
		Postpositivist	**Constructivist**	**Critical Realist**
Lens of	**Researcher**	Triangulation	Disconfirming evidence	Researcher Reflexivity
	Participants	Member Checking	Prolonged engagement	Collaboration with experts and project level participants
	Reviewers/Readers	Audit Trail	Thick, Rich Description	Peer Debriefing

Creswell & Miller (2000) explains 3 stages in collaboration; Prebriefing, discussion and debriefing. The application of the stages in Studies 1 and 2 are explained below:

- ***Prebriefing:*** Before the interviews and focus groups in Studies 1 and 2, discussion was held with gatekeepers and key contacts in companies to ensure:
    - The selection of participants was done to achieve objectives effectively and holistically.
    - The development of objectives with respect to expectations from researcher and company representatives.

  Prebriefing also had informal aspects, spending time in the companies by having extensive guidance to the office structure, introductions to senior management; gave the researcher an understanding of the company's organisational culture and the local industry culture.

  During the Prebriefing of the Study 1 project management firm, it was decided that participants involved at different stages of the design and construction must be relatively equally recruited in order to avoid one perspective having higher influence. Similarly, in Study 2, focus group participants needed to be a mix of experience levels of professionals in project delivery.
- ***Discussion:*** Before, during and after the interview or focus group, informal discussion was used to enhance the researcher's understanding of the participant's perspective.

Before the session, the firm, the participants role, and career background were spoken about. This enabled better understanding of the participant's personal characteristics allowing for more efficient data gathering e.g., more introverted participants required more probing, passionate/excited participants needed moderation.

Each session began with an open question about collaboration; its definition, current state, whether it needs to be improved, and what could be improved. This was significant to the researcher as it assisted in determining the research objectives indirectly without exerting pressure on the participant.

During the interview/focus group, the participant(s) was asked for definitions and clarifications to avoid misunderstanding of subjective inferences. These clarifications/definitions and all informal data (after receiving consent) were part of the transcribed data.

- ***Debriefing:*** Empirical findings were discussed with both gatekeepers after transcription and early stages of analysis in a consistent manner. Furthermore, analysis and discussion of findings were disseminated to participants via gatekeepers, in the form of feedback and publications. Harper (2003) explains the use of quantitative confirmation of qualitative outcomes, however, the model and evidence are a summative representation on content from a variety of sources including the researcher's analytical perspective developed from literature and experience. Therefore, it is unlikely that participants could reliably spot their own contribution. This is potentially due to the high complexity of concepts that emerged depending on factors from multiple levels.

Collaboration with participants was enabled by the semi-structured approach to interviews and focus group discussions; participants put across their views on project level collaboration and were asked to question the causes of challenges in collaboration. Furthermore, collaboration also occurred with the gatekeeper of both Studies 1 and 2, who were involved in the development of the model and development of the unstructured questioning approach. The Study 1 gatekeeper was an employee of the project management firm who was involved in innovation management. This put the gatekeeper at the optimal position to select participants who are involved in the design and construction process, to ensure that participants were relatively equally selected in the end to end process. The Study 2 gatekeeper was an academic with an interest in the research; with strong relationships and arranged focus groups with six firms in Norway with the motivation to cover all the major stakeholders in design and construction process shown in Table 9.

Furthermore, the differences in Studies 1 and 2 research design is a form of internal validity as this offers two different perspectives to the central interview/discussion question regarding effective collaboration.

Yin (2009) suggests that qualitative researchers need to document the procedures of the case studies. Creswell and Creswell (2018) suggests eight ways to ensure validity of qualitative data by using multiple strategies in order to enhance the researcher's and reader's ability to assess accuracy of findings. The following strategies were adopted: (Creswell & Creswell, 2018: p. 200–201)

- ***A 'rich and thick description' to convey findings:*** detailed description of the setting of the study, discussion of shared experiences of the researcher. Offering multiple perspectives of a theme. In relation to this research, 3 studies were conducted, and the majority of themes overlapped, this is shown in the discussion in Chapter 7. Evidence is taken from all three datasets to explain the interaction between themes using participant quotations.
- ***Clarification of the bias the researcher brings to the study:*** There is need to declare the biases and irregularities brought in by the researcher's reflexivity which plays a part in subjective interpretation as suggested by researchers who conduct naturalistic inquiries (Lincoln and Guba, 2001). Section 9.3 provides a reflective account to ensure clarity and transparency in the evaluation and analysis process; the researcher is embedded in the analysis and interpretation, therefore knowing more about the researcher puts the analysis in perspective.
- ***Internal triangulation:*** different sources to study the same problem is utilised. Study 1 used semi-structured interviews whereas Study 2 used focus group discussions.
- ***External triangulation:*** involved comparing findings with existing knowledge found in the literature review. Both forms of triangulation are utilised. In Chapter 6, the model's structure is validated by triangulating results with literature. In Chapter **Error! Reference source not found.**, focussing on narratives surrounding the meso level, literature and expert semi-structured interviews were used to validate and locate gaps in the data.

Qualitative reliability techniques explained below were utilised (Gibbs, 2007):

- Checking if transcripts do not have obvious mistakes during transcription
- When the coding process was conducted, the definition of codes was kept consistent by referring to the original recordings and transcripts
- Cross checking codes and findings with literature (shown in Chapters 6 and 7), literature related to the finding was used to provide the reader with a comprehensive documentation of the relation between codes/themes or the application of a theme/code.

The use of individual expert interviews is common in social research (Bogner et al., 2009). Confirmatory expert interviews were conducted with open semi-structured questions (found in Appendix H) and reflection of the model/results from Studies 1 and 2. To limit the emergence of bias responses and to ensure a genuine perspective, the factors themselves were not shown to

the experts until the end of the interviews. From these interviews, the structure of the model was confirmed, changes to the model made and gaps/discrepancies in the data identified. These aspects are discussed in Chapter **Error! Reference source not found.**.

As part of research's interpretive traits; a dialectic and hermeneutic method is used (DeLuca, 2011). Table 12 shows the meaning and how it applies in this research.

Table 12: Validity Enhancement in Research with Interpretivist Traits (DeLuca, 2011)

Key Aspects	Definition	Way validity can be achieved	Way validity is achieved as part of method's design
Dialectic	Multiple theoretical perspectives in a pluralistic dialogue e.g., ongoing critical reflection (Moss, 1998)	Utilising diverse methodological perspectives to interact (Messick, 1987; Moss, 1998)	Focus groups, individual interviews, expert interviews have variant perspectives. Varied geographical locations and types of participants and firms to allow divergence in methodology and convergence in findings.
Hermeneutic	Interpretation of evidence	- Biases and prejudices in participants/researcher can be brought forward (Moss et al., 2006) - Recurrent data collection (Maxwell, 2004)	Participant – background and history of participant is collected at beginning of each session; semi-structured approach gives participant chance to put across opinions and gives participant indication of participant personality and bias. Researcher – Reflective Account (Section 9.3) declares researcher bias.

Furthermore, research with interpretivist traits are also said to be transgressional in nature, meaning that the subjective process of qualitative research is acknowledged (Maxwell, 2012); 'validity is multiple, partial and endlessly differed' (Lather, 1993: p. 675). Therefore, the analysis and validation use literature to evidence key links made in the research, to bring some external validity. Furthermore, by utilising semi-structured expert interviews, key empirical findings have enhanced validity.

Validity of interpretive research has been discussed in the construction management domain by utilising Unique Adequacy (UA) requirement. This requirement is a criteria by which the products of research are evaluated (Rooke and Kagioglou, 2007). Two forms of the requirement are utilised; the 'weak' form refers the information that the researcher needs to put the data collected into context of the participant and their setting, whereas, the 'strong' form refers to the way researchers make judgements suggesting that there is need to exclude judgements from outside the research context (Rooke and Kagioglou, 2007). The 'weak' form of UA

requirement was achieved by starting interviews/focus groups with detailed accounts of the participants' work, role and attitude. The 'strong' UA requirement was achieved by utilising gatekeepers to check the validity of the judgements made based on the data collected. This was crucial as gatekeepers belonged to the local industry/community and therefore assisted the researcher in ensuring that the judgements made are consistently interpreted within the context.

4.9 Summary

This chapter outlined the methodology adopted in collecting and analysing the qualitative data shown in Chapter 5. Table 13 summarises the methodology in relation to sub-research questions shown in Table 1.

Table 13: Summary of Methodology in Relation to Sub-Research Questions (SRQ)

Research question		Quantitative	Literature Review	Qualitative		Sense-making	Thematic Analysis
		Survey		Semi-Structured Interviews	Focus Groups		
SRQ1 Chapter 3	Can project level collaboration be measured?	√	√	√		√	√
SRQ2 Chapter 4	What methodological paradigms are suitable to understand the reality of project level collaboration?		√				
SRQ3 Chapter 2	What factors affect project level collaboration according to project level practitioners?		√	√	√	√	√
SRQ4 Chapter 5	How can the factors that affect collaborative environments be visually interpreted?		√			√	
SRQ5 Chapter 6	Which factors are most practical to change and impactful in driving industry wide change to suit project level collaboration and implementing digitalisation?					√	
SRQ6 Chapter 7	How do expert views from literature and practice compare to project level views?		√	√		√	√
SRQ7 Chapter 8	How are factors rooted in Human Psychology and Culture (HP&C) valued in the AEC industry compared to similar industries?		√			√	
SRQ8 Chapter 8	How can AEC collaboration models be adapted to suit realistic nature of factors?		√			√	
SRQ9 Chapter 8	How are the psychological and social aspects affecting project level decision-making and collaboration at the meso level?		√			√	
SRQ10 Chapter 8	How is the meso level affecting the mentality of collaboration and implementation of digitalisation at the project level?		√			√	

5. ANALYTICAL RESULTS

5.1 Introduction

The following chapter presents the qualitative outcomes. Empirical evidence from both studies is narrated individually in Sections 5.3 and 5.4. The structure of the chapter is with respect to the most emergent themes (shown in Section 5.2) with the aim of allowing transparency of interdependent factors that result in symptoms or issues. Due to the high interdependent nature of themes or factors found in the qualitative data, the narratives are split into two parts; human factors and project factors. Project factors are defined as in the IDDS model (Figure 1) which refers to the tools and process part of collaboration. Human factors refer to the 'people' part of the IDDS model.

The themes and keywords are defined contextually as shown in Appendix A. Although, these two parts cannot be perceived as completely split due to the integrated nature of the data collected, human/project factors emerge as interdependent in numerous scenarios. The narrative is structured surrounding the most mentioned themes. Each description of data is followed by a quotation, more supporting quotations can be found in Appendix I. Each section in the narratives also has a summary diagram which follows the structure of the Holistic Model for Collaboration in the AEC industry (HMC-AEC) presented in Chapter 6. Each issue/symptom can be perceived as a postulated claim comprising of interacting factors or themes within the HMC-AEC. The objectives are:

- To visualise and comprehend empirical factors drawing out the most significant themes and factors using thematic analysis (SRQ3)
- To understand the factors that affect collaboration at the project level from empirical evidence (SRQ3)
- To understand the interactions of factors that affect collaboration at the project level from empirical evidence and literature to develop a general model from interactions (SRQ3 and 4)

5.2 Thematic Coverage

This section seeks to provide understanding of the quantity of data represented by each theme; to show the differences (if any) of perspectives with respect to the profession of the participants. When analysing these results, it is important to keep in mind that the approaches (interviews vs focus group) and profession of participants varied in both studies (as shown in Table 8); therefore, content variation cannot be avoided as there are methodologically lead differences in perspective. Both approaches involved semi-structured data collection where the participant's intuition and experience are utilised to draw conceptual understanding. The results cannot be held as primarily conclusive because it involves the use of the researcher's sense-making which is subjective and variant depending on the researcher. However, they are developed to:

1. Understand the main factors that emerged in the study so that the results section can be structured optimally according to the data collected
2. To give the reader an overall idea of the contents of the data collected

Table 14 shows the percentage coverage of themes in each study, this can be perceived as the number of times a theme was referred to between the participants in either study. The themes highlighted in yellow emerged in both studies. This table gives a holistic view of the data collected and a comparison between the studies is made. However, due to the subjectivity brought about by the unstructured data collection strategy, it was important to differentiate between the number of times a theme emerged and how many types of participants mentioned a theme. The latter is presented in Table 15. In other words, Table 15 shows the coverage of themes across subgroups representing the coverage across disciplinary driven perspectives. Subgroups in Study 1 were defined based on the current role of participants which were clarified at the beginning of interviews; participants were either only involved in design/production or were involved in both (end to end). Subgroups in Study 2 were defined by the type of firm the focus group was conducted with.

Table 14: Coverage of Themes in Studies 1 and 2

Themes	% Coverage in All Data	
	Study 1	Study 2
Accountability	0.7	0.3
Attitudes	1.3	3.0
Change Management	5.5	10.8
Client Decision-making	3.5	1.2
Client Finance	1.5	0.3
Client Involvement	1.3	2.4
Client Knowledge	3.5	2.1
Client Organisational culture	2.0	1.0
Client Requirements	1.3	1.9
Comfort	1.8	0.7
Contracts	5.5	4.9
Data Exchange	10.2	15.5
Decision-making	2.0	0.5
Financial	4.0	1.9
Goals	1.5	1.4
Hierarchy	0.2	1.2
Holistic Understanding	1.8	4.0
Informal Information	0.7	0.3
Leadership	4.0	2.4
Liability	3.1	2.1
Local Culture	8.2	5.9
Local Policy	0.7	1.4
Motivation	2.9	1.2
Openness	3.1	0.7
Organisational culture	1.3	6.1

Themes	% Coverage in All Data	
	Study 1	Study 2
Personality	4.4	1.0
Planning	0.7	0.5
Process Management	7.1	7.0
Procurement	0.9	2.6
Relationships	5.7	4.7
Stakeholder Accountability	0.7	0.7
Team Selection	2.2	0.5
Trust	2.9	1.4
Belief	N/A	0.3
Business Models		1.9
Competition		0.5
Discipline Specific		0.3
Education/ Learning		1.4
Facility Management		0.3
Heuristics		0.5
Quality		0.3
Respect		0.5
Rewards		0.7
Technical Competency		1.2
Client Emotion	0.2	N/A
Collective Ownership	0.9	
Discipline Oriented Knowledge	1.1	
Education/ Learning	0.2	
Experience	1.1	
Fragmentation	0.4	

Note: Themes in yellow emerged in both studies

Table 15: Cross Perspective Coverage of Themes Between Discipline-Based Subgroups

	Subgroups from Study 1			Subgroups from Study 2					
Themes	Design	Production	End to End	PM[1]	PO[2]	Contractor	Public Client	Consultant	Coverage Across Subgroups (%)
Change Management	●	●	●	●	●	●	●	●	100.0
Contract	●	●	●	●	●	●	●	●	100.0
Data Exchange	●	●	●	●	●	●	●	●	100.0
Goals	●	●	●	●	●	●	●	●	100.0
Industry Culture	●	●	●	●	●	●	●	●	100.0
Leadership	●	●	●	●	●	●	●	●	100.0
Process Management	●	●	●	●	●	●	●	●	100.0
Procurement	●	●	●	●	●	●	●	●	100.0
Business Model	●	●	●	●		●	●	●	87.5
Client Involvement		●	●	●	●	●	●	●	87.5
Client Knowledge	●	●	●	●	●		●	●	87.5
Client Requirement	●	●	●		●	●	●	●	87.5
Financial	●	●	●	●	●	●		●	87.5
Motivation	●	●	●	●	●	●	●		87.5
Organisational culture		●	●	●	●	●	●	●	87.5
Technical Competence	●		●	●	●	●	●	●	87.5
Fragmentation		●	●	●		●	●		75.0
Liability		●	●	●	●		●	●	75.0
Local Policy	●	●			●	●	●	●	75.0
Planning	●	●			●	●		●	62.5
Stakeholder Accountability		●	●	●	●			●	62.5
Rewards		●		●			●		37.5
Client Finance					●			●	25.0
Client Organisational culture		●			●				25.0
Competition						●		●	25.0
Education						●		●	25.0
Colocation						●			12.5
Facilities Management							●		12.5
Human Resources	●								12.5
Quality							●		12.5

[1]Project Management, [2]Professional Organisation

Legend	12.5%	25%	37.5%	50%	62.5%	75%	87.5%	100%

5.3 Study 1 - Finland

The following section focuses on the data collected from a Project Management (PM) firm in Finland. This section is structured based on the most emergent and significant themes as shown in Table 14 and Table 15 or Figure 24 and Figure 25. Study 1 comprised of data collected from one of the most innovative PM firms in Finland with a flat hierarchical organisational structure. The firm is capable to provide leadership through design and/or production phases of an AEC project. Table 16 shows the structure of this section in reference to the relevant themes analysed.

Table 16: Overview of Themes Analysed from Study 1

Section	Theme
5.3.2.1	Contracts, Business Models, Procurement
5.3.2.1.1	Risk and Reward in Contracts
5.3.2.1.2	The Contract and Procurement Strategy's Impact on Leader's Ability to Control End to End Process
5.3.2.1.3	Team Selection (Procurement)
5.3.2.2	Process Management and Data Exchange
5.3.2.2.1	Leadership Difficulties Regarding Process Management
5.3.2.2.2	Informal Information
5.3.2.2.3	Holistic Development of Process
5.3.2.3	Change Management
5.3.2.3.1	The Effect of Technological Change
5.3.2.3.2	Idealised Change
5.3.2.3.3	Comfort in Changing Routines
5.3.2.4	The Client
5.3.2.4.1	Client Knowledge and Involvement
5.3.2.4.2	Client Trust
5.3.2.4.3	Client Organisational Culture
5.3.3.1	Language and Geographical Industry Cultures
5.3.3.2	Relationships, Trust and Openness
5.3.3.2.1	Relationships and Trust
5.3.3.2.2	Relationship Development
5.3.3.3	Personality
5.3.3.4	Holistic Understanding and Thinking

5.3.1 Thematic Structure and Interactions

Two diagrams were developed to gain a visual understanding of the complexity of interactions which assisted the researcher to comprehend a holistic view of the data.

Figure 24 shows the interactions between project themes that emerged in Study 1. Data collected from one project management firm comprised of 18 interviews with participants involved in parts of the end to end construction process. The data was split into three subgroups, depending on the role of the participant; design, production and end to end. The different colours of nodes in show the level of coverage across the subgroups. The underlying hypothesis was that

people associated with different parts of the end to end process would have similar views. Figure 25 shows the thematic interactions found from Study 1 focusing on the human themes such as relationships, trust, openness, decision-making, attitudes etc. (all the themes are represented by bold characters). The figure was developed to show the interactions between human aspects (which are non-controllable) and project aspects. Like in Figure 24, the colours of nodes and thickness of arrows represent the coverage of the connection/theme.

Although a split was made between project and human aspects, it is evident that the two diagrams are to be perceived as one coherent set of interacting factors; they should be perceived as two different viewpoints of the same data where the lens project factors is used in Figure 24 and human factors in Figure 25, each is prioritised to visualise over the other.

The narratives in Sections 5.3.2 and 5.3.3 surround themselves amongst the most discussed themes which were sub grouped depending on the relevance and connection found in the thematic structure; e.g., contracts, business models and procurement were coherently discussed by participants and related to other factors of collaboration, to ensure maximum value and to avoid misperceptions due to overly isolating data.

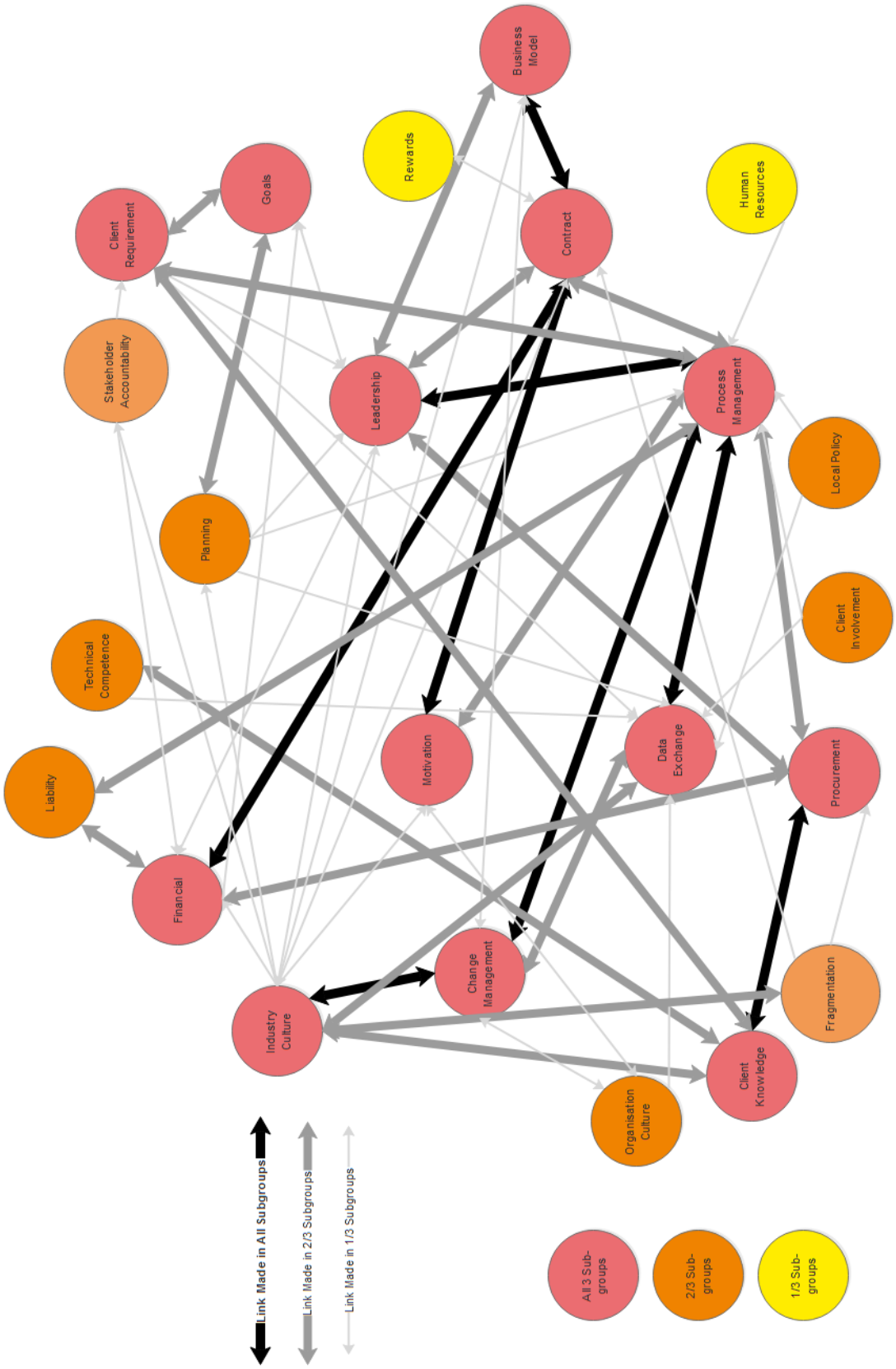


Figure 24: Thematic Interaction of Project Related Factors in Study 1

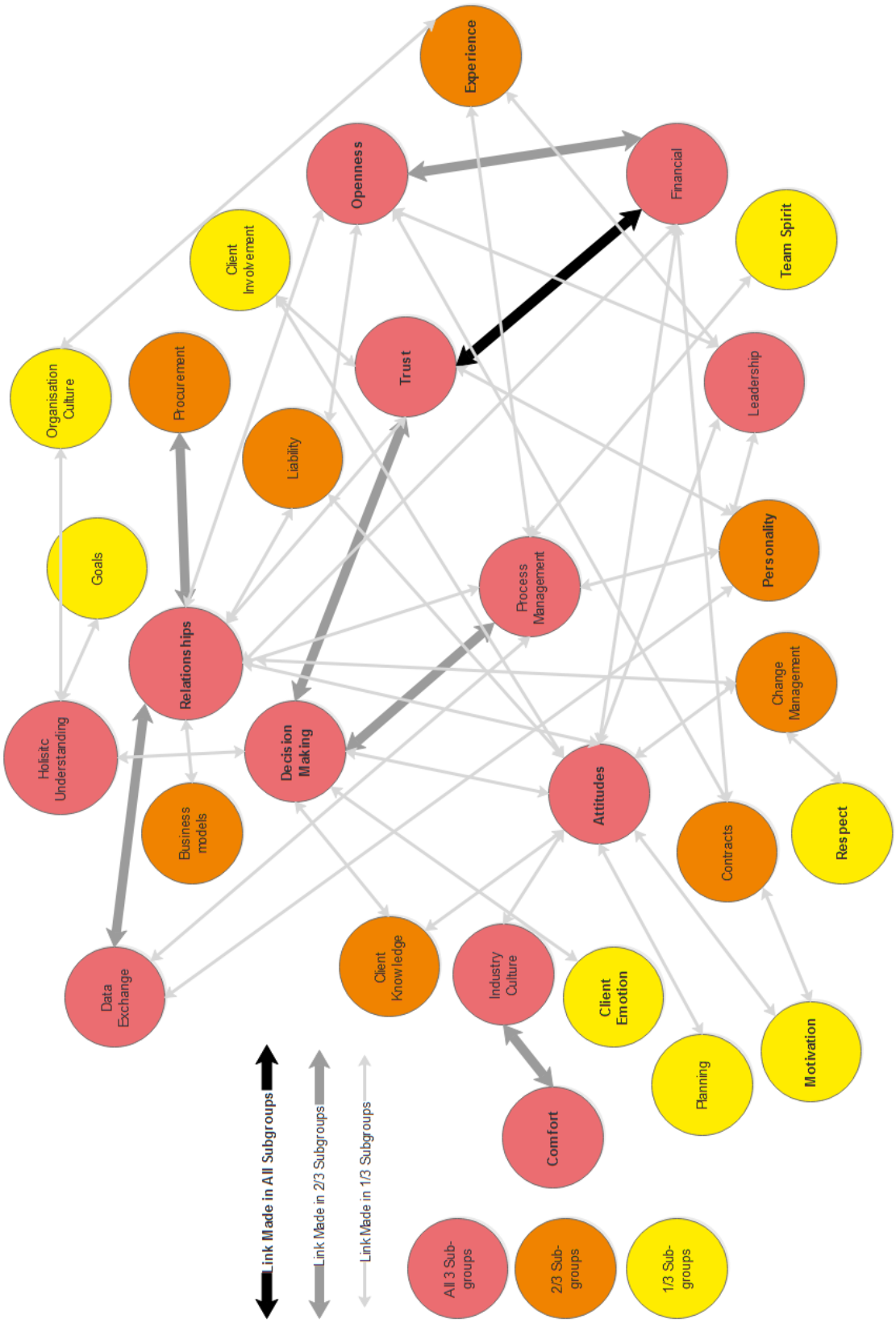


Figure 25: Thematic Interactions Between Human and Project Factors in Study 1

5.3.2 Narratives Centred Around Project Based Themes

The section presents narratives surrounding project management themes. A holistic view of the data surrounding an aspect is presented and supporting quotations given below a description. Other quotes can be found in Appendix I. Summary diagrams throughout the section show the links made between phenomena.

5.3.2.1 Contracts, Business Models, Procurement

The importance of contracts in incentivising a positive collaborative environment is evident from the effect on people's attitudes. A participant explains that even though teams may have good inter-personal chemistry, if the contract brings out a blame-based culture it results in a poor environment:

> *'Sometimes you have 2 good people and when the project is going bad they want to make sure that they are not the one who is going to get blamed even when the other one thinks like that, Good people in a bad environment can also become bad. The contract is responsible for partly incentivising that environment and way of thinking.' (16, Research and Development, End to End)*

The sub-sections explain the issues that emerged surrounding the contract, procurement and business models.

5.3.2.1.1 *Risk and Reward in Contracts*

The effect of shared risk and reward in contracts emerged in 30% of interviews (6/18) held in Study 1 in reference to a commonly known contract in Finland referred to as Alliance (Alhava et al., 2015). In Alliance contracts, risks and rewards are shared between key stakeholders. Therefore, participants that had experience in Alliance contracts showed positive effects; willingness to share information, reduced susceptibility to blame-based attitudes, more use of holistic thinking enabled by more unity in incentives and improved motivation of individuals. In comparison to the traditional contracts, positive client feedback reiterates the positive nature of effects. Although, barriers to implementing the shared risk and reward contracts come from the need to educate practitioners, changes in administration, accounting and the need for more client involvement. Additionally, the fragmented nature of the Finnish industry could result in higher overall project risks as firms take up smaller roles; the other teams need to share this increase in risk. In summary, it is suggested that barriers to using a new method of incentivising teams brings about changes to the processes at the project level inflicting changes in how firms produce value in the business model. The less susceptibility to blame suggests reduction in conflicting intrinsic and extrinsic motivation; the individual drive to innovate and collaborate is not clashing with their firm's need to protect profits.

> *'in the last Alliance contract, we created a group… the owner and client, general contractor, designers and 3 sub-contractors… all the parties sign and if there is a problem, we all pay for it as we are collectively responsible. Share the pain, share the gain…the client always pays the actual cost of the work, if we later find out that there is a problem, we will fix it but the client will pay us the cost price (no profit) and there*

are also target prices for the whole project and so if we get under that price the teams get bonuses' (16, Design Manager, Design)

'In Alliance and project management projects people are more willing to share information but lump sum project teams are not as motivated as they think that there is a higher risk in sharing. When it comes to arguing they have some leverage in the lump sum projects... I believe in the project model, common risk, common revenue but we need to adopt it in the right way. Small roles can cause a lot of damage, but they don't take the penalty, everyone does even though it was their fault. Finnish industry is highly fragmented, more players in an Alliance project brings in more risk' (3, Process Management, End to End)

'Alliance contracting forces them to work together and trust each other, they will see everything openly and that is really useful' (18, Design Manager, Design)

Figure 26 shows a summary of the links made in this section.

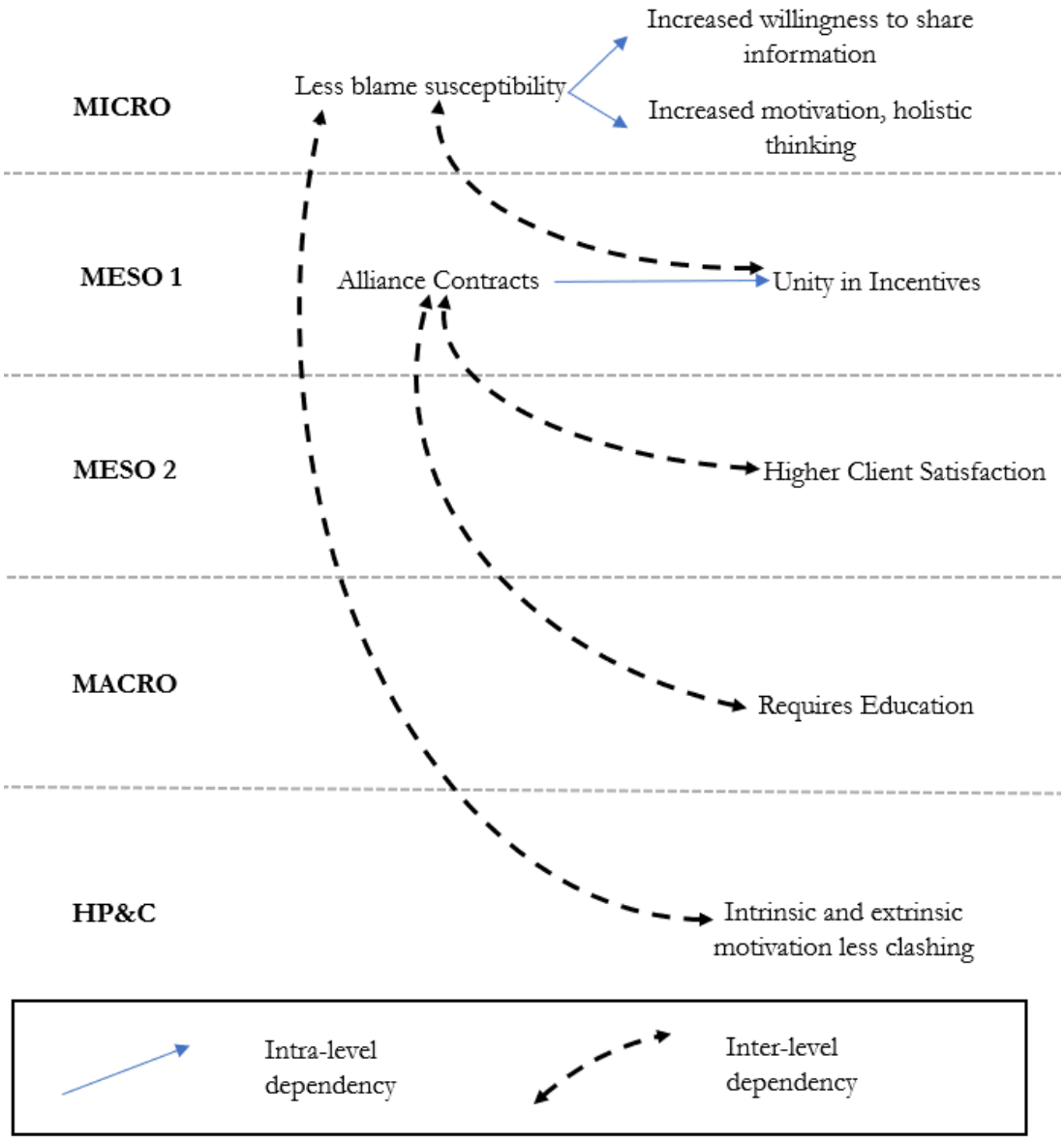


Figure 26: Summary of Section 5.3.2.1.1

5.3.2.1.2 The Contract and Procurement Strategy's Impact on Leader's Ability to Control End to End Process

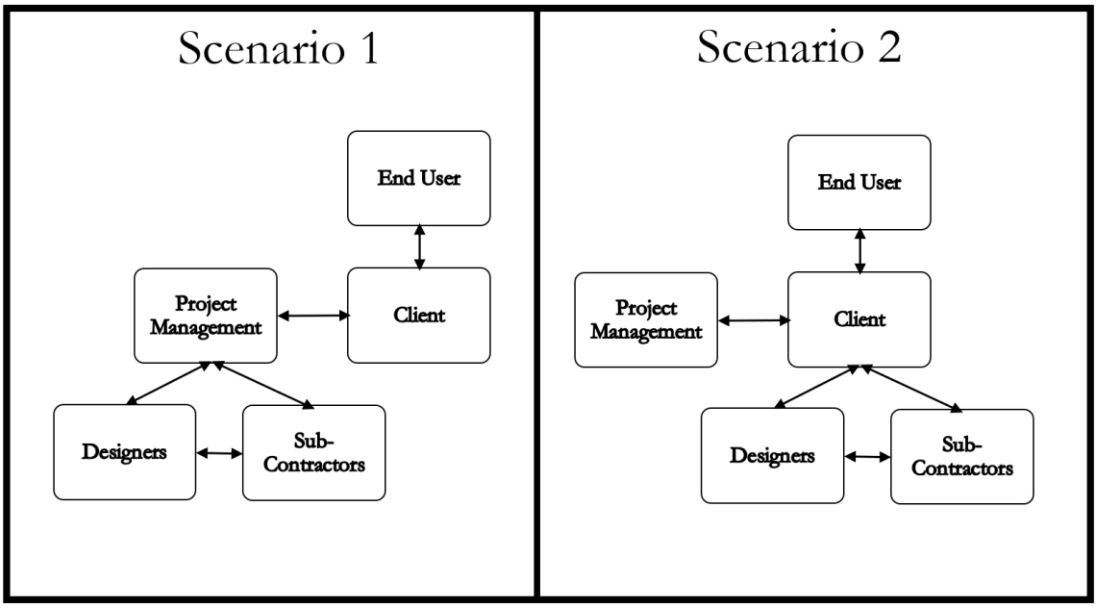


Figure 27: Business Model of Project Management Firm (Left – 'Ideal', Right – 'Restrictive')

The ability of the leader to control project level processes was related to contracts and procurement; described by 39% of participants (7/18) to affect the collaborative environment. Figure 27 shows two business models with the Project Management (PM) firm which created different project behaviour. The ideal scenario (left) is if the client trusts the PM to allow them to select teams and control the management of the project, if not, the sub-contractors and designers are usually contracted under the client (right).

Participants had similar perceptions regarding the handicap of the contractual/procurement regime on the firm despite their personal role, a consequence of the scenario with the restricted contractual position (Figure 27-Right) was when the PM firm is not contracted to manage the design process. This influences the social climate of the project resulting in later modifications from suboptimal design solutions bringing susceptibility to disputes as a result of **inconsistent and insufficient transfer of information between project lifecycle phases** (design and production). Additionally, a loss in **motivation** of design teams was linked to the restrictive business model's discontinuous nature between design and construction.

When comparing working with designers contracted via the firm (Figure 27 - Left) and vice versa (Figure 27 - Right), the ability of the PM firm to control teams is lost because of the inflicted **loss of leverage**. The restrictive business model also results in **inconsistent leadership**; the leader is not contracted for the whole process of design and construction. This results in lower PM firm authority on other firms and has consequences on the social climate between the teams; the client is usually not equipped to manage these relationships. Additionally, loss of authority was also said to negatively influence the potential to optimise project level processes. It is

inevitable that the contractual position of the leader restricts or alleviates the possibilities to develop processes and solutions to suit a positive collaborative environment. Additionally, the inconsistent leadership shows the interdependence between the design and production phase. This is further complicated as the contractual processes vary between the design and production phases; liability and rewards vary as a result of fragmentation and the nature of work.

> *'it is easier to communicate with designers we contract rather than when the designers come from our client, the situation might be that there is work done or plans ready. We don't have the opportunity to influence the design solutions with respect to constructability and production. It depends on who is the one paying the designers, usually we have situations where we want to make changes to make the solution more efficient, then there might be more debates with the designers employed with the client. It's more difficult to make the changes' (2, Schedule Management, End to End)*

Figure 28 shows a summary of the links made in this section.

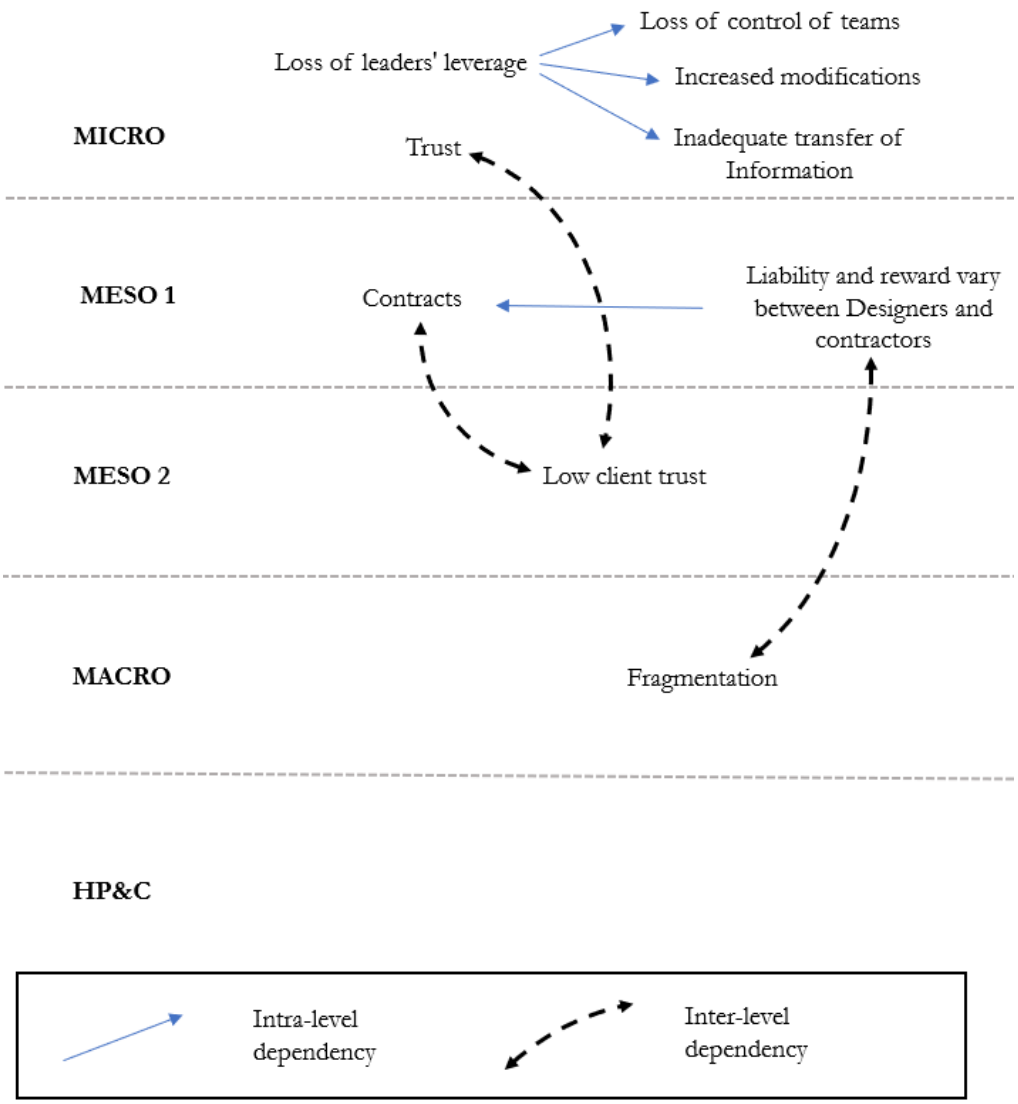


Figure 28: Summary of Section 5.3.2.1.2

5.3.2.1.3 Team Selection (Procurement)

Acting as an enabler for optimal selection of teams, the Alliance contracts places importance in selecting the right teams before tender; driven by the open financial models, a condition in the contract. Discussions about advantages of Alliance contracts were centred around selecting and managing people appropriately. The importance of choosing the right people was linked to uncontrollable aspects of human factors influenced by e.g., personality and trusting attitude involved in fostering positive relationships between teams.

An important factor that emerged was trust which was mentioned in all interviews in relation to collaboration. The preference to interact with **open individuals** was mentioned in all 8 interviews that personality emerged in. Although selection is important based on the characteristics of teams, there is also a nurturing effect in collaborative teams:

> *'Good people in a bad environment can also become bad' (16, Research and Development, End to End)*

This suggests that there are **environmental or contextual factors affecting one's attitude** e.g., depending on the way a team is affected by **liability**, as after all, the individual is paid by his/her company and not the project.

When asked about traits that are important when selecting teams, **the openness of teams** employed by the firm is brought forward as an important factor and linked to the ability to think holistically. The ability to cooperate between teams was suggested to be sometimes uncontrollable showing that creating trust with a team is not always possible.

The effect of an existing relationship with a team is in clearer expectations of the cooperation between the team and the PM firm. Furthermore, with previous experience working with the PM firm, it was suggested that the designer's **holistic understanding of construction processes** emerges as more likely to be developed. This pertains to the initiatives taken by the firm in having 'Verstas' meetings. These meetings involve with open discussion and solving inter-disciplinary issues dynamically, also known as intensive big rooms (Alhava et al., 2015). Participant raises the need for teams to understand the impact their work has on the other teams, playing a part in selecting the right team to collaborate with.

Although participants explained the importance of putting people first before cost, **price-based selection** is still the normative way of selection. Furthermore, the dependency of the team selection process on the client became evident, as it depends on the trust the client gives the PM firm and the agreement, they have with them.

> *'I like the Alliance contract because, at the tender stage, the client asks you who your teams are, I want to meet them, and they are choosing people and then comes the money. Choosing the right people is the most important part of it…if you don't pick the right people in the beginning even though the systems and training is good, it can be difficult' (16, Research and Development, End to End)*

> *'Sometimes we only recommend the sub-contractors to the client and they will choose, we prefer to make the selection as we usually have more experience working*

with them and understand what we are looking for' (13, Production Manager, Production)

Figure 29 shows a summary of the links made in this section.

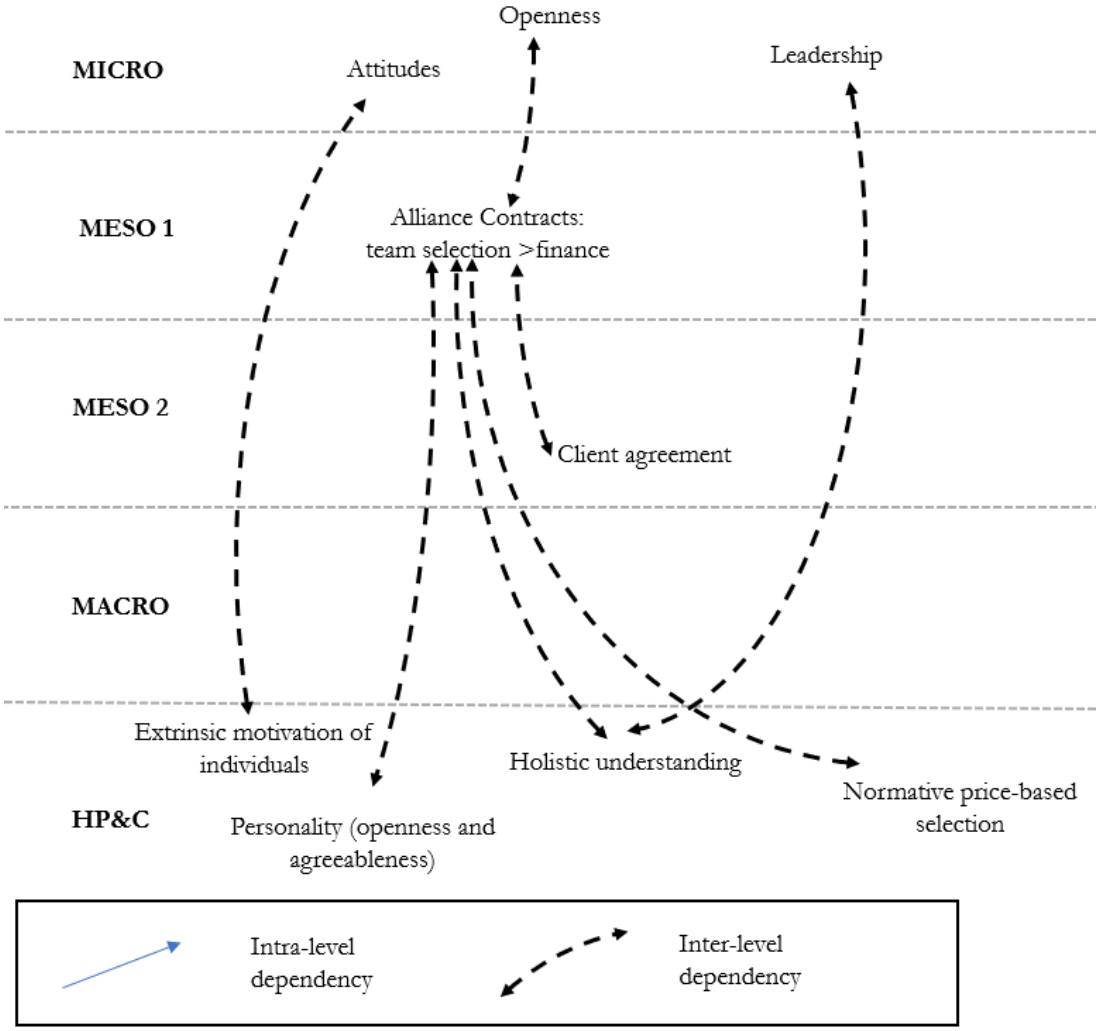


Figure 29: Summary of Section 5.3.2.1.3

5.3.2.2 Process Management and Data Exchange

The process of information exchange and decision-making is found to affect human behaviour.

'How the process works is affecting the people. People get frustrated and they don't give their best' (18, Project Manager, Design)

Figure 30 shows a summary of the links made in this section.

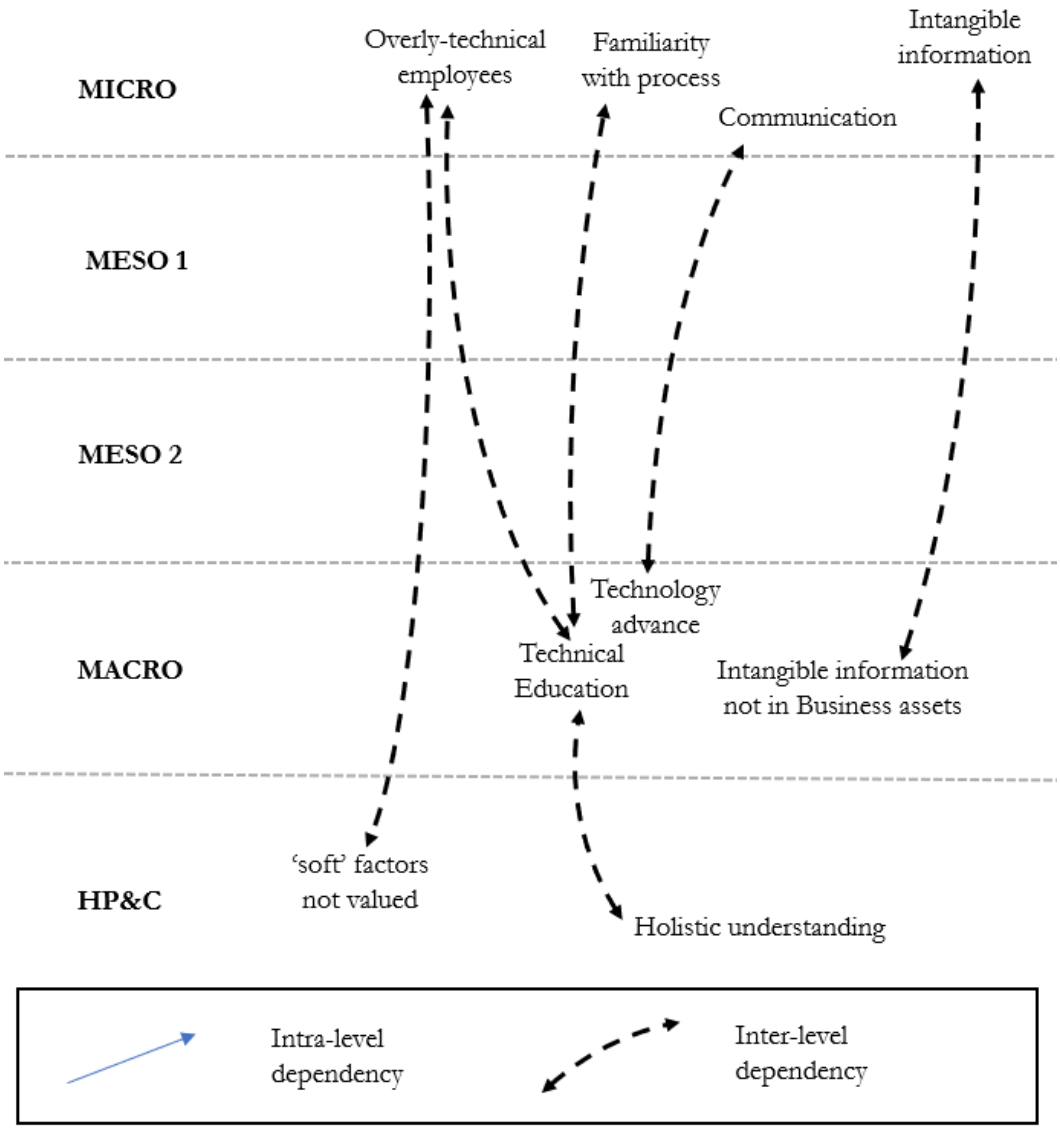


Figure 30: Summary of Section 5.3.2.2

5.3.2.2.1 Leadership Difficulties Regarding Process Management

Coordinating information in the design phase is one of the leader's responsibilities. **Familiarity with the way that the leader coordinates information** is important as there are multiple ways to coordinate. A participant explained the **variety of choice in process management** suggesting that optimistic and pessimistic personalities choose different processes and therefore a challenge to the leader in developing processes. The variety of choice also suggests high variance in the way people are educated to manage the process or raises whether they are taught to manage the process. Another participant linked process development to the need for better decision-making processes in relation to coordinating information.

> *'Clearer decision-making process is needed because if one designer is going too deep then he is wasting his time and it affects their behaviour and it makes them upset' (18, Project Manager, Design)*

> *'There are too many ways to work, some people are too positive and some negative so they choose depending on their personality, more positive people want to try*

something new and the more negative people will focus on the limitations' (2, Schedule Manager, End to End)

5.3.2.2.2 Informal Information

28% of participants (5/18) explained one of the difficulties in managing the construction project from end to end as **the lack of transfer of informal information** (non-technical tacit information). The need to record information from experiences and decisions emerges as an asset to the business. The lack of transfer and record of informal information suggests the **lack of dynamic forms of communication** and an over-reliance of businesses on people.

The lack of transfer of informal information makes people critical to a project, this was further supported by the effects of changing people at a further stage. When probed to question the root causes of this lack of transfer, the technical nature of employee's education was suggested to be reasons for this lack of transfer. Additionally, the changes of human resource were suggested to alleviate discrepancy in informal information as a result of lower human contact when exchanging information.

'What is written on paper is not enough when moving from one stage to another – chemistry of people is important, based on experience, drastically removing and changing people can upset the project chemistry…we are in a technical industry, most of them are thinking in a technical way, they don't value the soft things' (8, Development Manager, End to End)

'…technical information is transferred okay but the informal stuff like experiences or thought processes are changing which are not recorded and transferred' (3, Process Management, End to End)

5.3.2.2.3 Holistic Development of Process

A participant explained the link between the way the Finnish education system works splitting design and production making the employees naturally believe that they are separate processes bringing about a 'stop-start' process and loss of information. Additionally, this suggests **a lack of holistic understanding**; the value of experience was related to the ability to think holistically in the end to end construction process. Information and experiences from later stages in other projects' lifecycle were expressed to not be used efficiently in developing an optimal solution e.g., maintenance requirements not used in design.

'The maintenance guys know the materials that are not working, and we don't have that information when they are designing. Transferring knowledge from stage to stage to improve our solutions, from the people who know about the end to the people who are working in the beginning '(16, Research and Development, End to End)

5.3.2.3 Change Management

Change management emerges as a result of discussions to do with technological changes in data exchange's impact on collaboration and the way these changes are managed both within one organisation and at the project level. Change management is therefore not about design changes/modifications. Figure 31 shows a summary of the links made in this section.

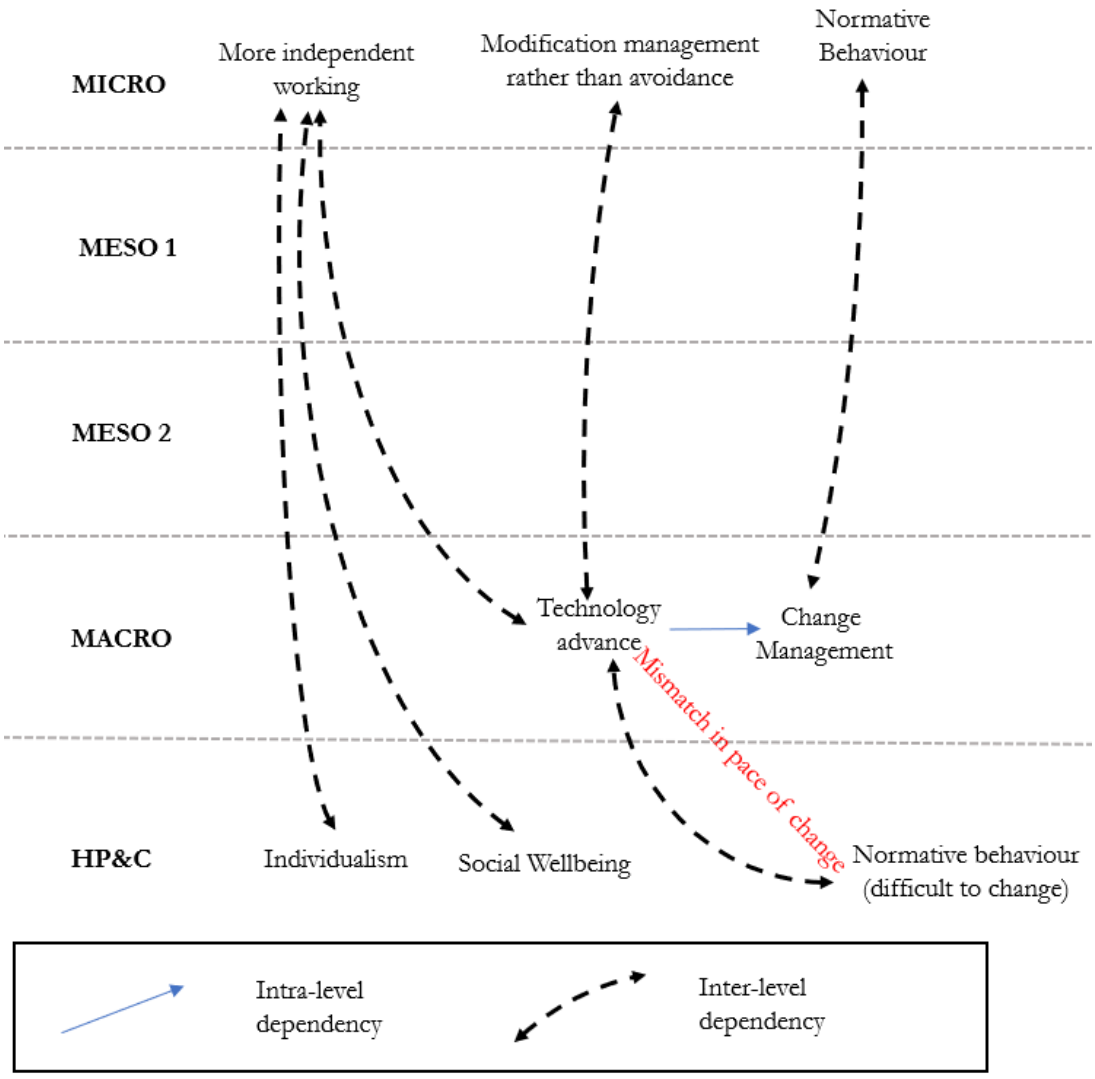


Figure 31: Summary of Section 5.3.2.3

5.3.2.3.1 The Effect of Technological Change

One of the firm's most experienced employees compares mentalities and attitudes before and after systemic changes driven by digitalisation began. The participant has been employed by the firm for more than 15 years and was first employed as a site engineer, at the moment, currently positioned as a development manager, involved in the end to end process. The participant reflects suggesting a change in mentality with regards to the way changes to the design solution (micro change management) are conducted:

> *'When I started working, no computers, ink pens, we used to sit together and draw. Changes were much more difficult to do, now, it's too easy to make changes with BIMM. There was the attitude that we have to work together to avoid the changes, now there is the attitude that we can make the changes easily so we don't necessarily have to work together… and this has evolved over the last 30 to 40 years… the mentality shifted, if we brought the mentality that they have to care about each other and apply it now, it would be much more efficient' (8, Development Manager, End to End)*

5.3.2.3.2 Idealised Change

When probed to question the way that digitalisation could be effectively utilised to improve collaboration, the participant reiterated the changes in attitudes of people driven by digitalisation resulting in more individualism enabled by technology; people are able to work independently on inter-disciplinary work.

When asked to elaborate on how the attitude should change, the leader's ability to motivate holistic thinking emerged. People are to be thought of as social beings, reassured when doing well, and motivated to think about the bigger picture.

The increased ease of making design changes from technological advances resulting in coordination challenges enables the mentality to 'handle' changes rather than prevent them:

> *'Attitude of the people needs to be changed, not the professional skills. Motivation and happiness in the industry for the people to help each other. The work is the same, the attitudes have changed, and this has been driven by technology' (8, Development Manager, End to End)*

5.3.2.3.3 Comfort in Changing Routines

The changes in digitalisation in the industry are also suggested by some participants to require people to step out of their comfort zones in their daily routine. This brings out fear of change.

People's attitude towards change also emerged when a participant describes the lack of comfort in changing processes. Reiterating the need for people to change and explaining that the speed of technological transformation is not being matched by people's transformation. Furthermore, there is an effect of normative behaviour as a result of businesses being static for 20 to 30 years in the industry; people are not used to change. Age and change also compared showed that typically younger people were grasping new ways of the industry faster than people with strong normative ways of working.

Using an example of 'Verstas' meetings, an alternative and more interactive form of meetings as compared to the traditional meetings, a participant that runs 'Verstas' explains the lack of participation and explains that this may be due to lack of comfort and/or belief because it is a relatively new practice in the industry.

> *'I think the biggest difficulty is that they are not familiar with Verstas usually they are meeting oriented, and they are used to a strict agenda for meetings. They way that we work in Verstas is usually with a rough idea or goal for the meeting and we try to delegate towards that goal. They are not used to that; it is really hard to get people to participate. Why? It might be that they don't see the value, or they are not comfortable. Once they see the value in one project, in the next project participation is a lot more positive' (11, Project Manager, Design)*

> *'It's very difficult for people to understand that the world is changing, it's not about attitudes about computers but it's about the acceptance of the process of change. They are scared of changing their daily routines' (7, Production Manager, Production)*

5.3.2.4 *The Client*

The data collected from Study 1 had 13.3% coverage of factors (from the entire Study 1 dataset) relating to the client indicating significance. All interviews had mention of the client relating to a variety of factors as shown in Table 14. Figure 32 shows a summary of the links made in this section.

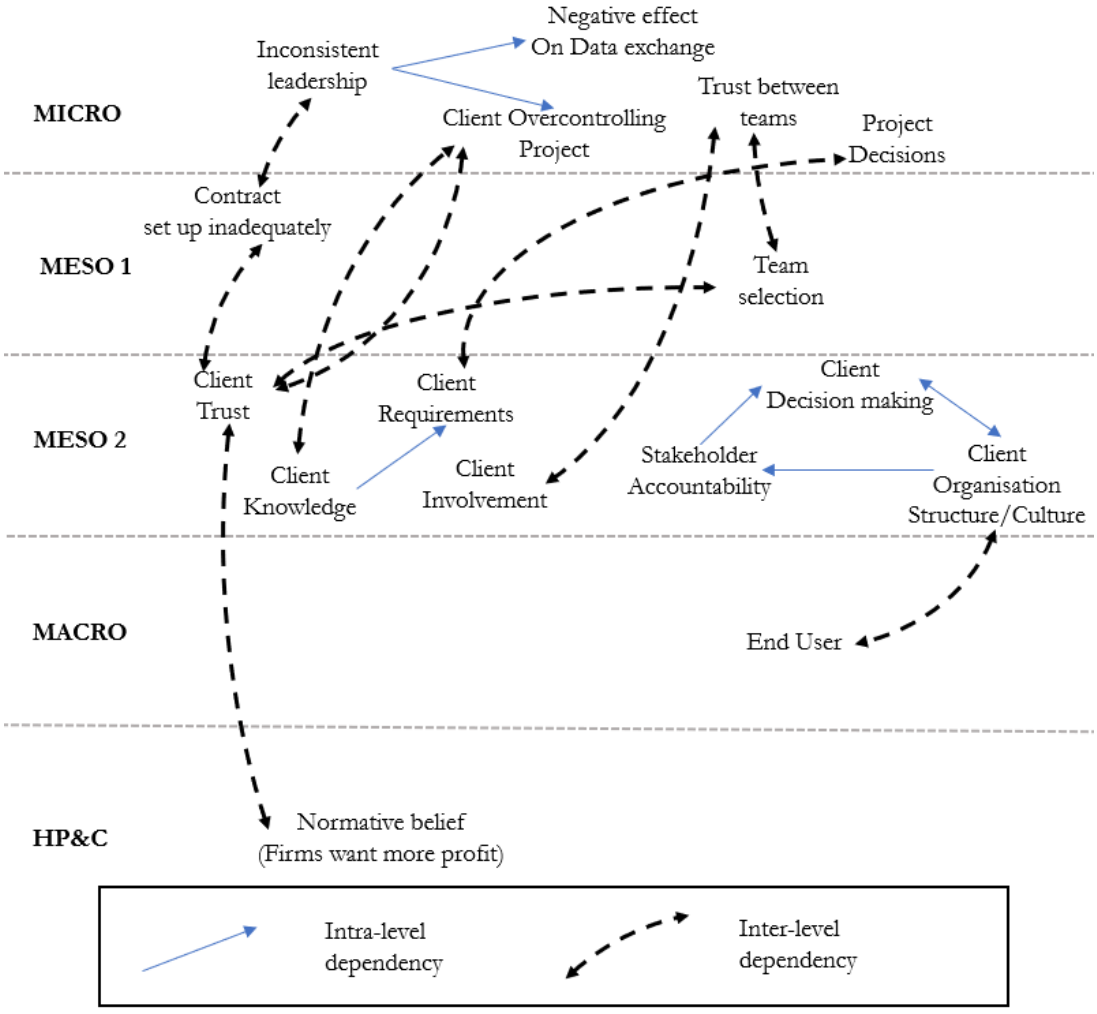


Figure 32: Summary of Section 5.3.2.4

5.3.2.4.1 *Client Knowledge and Involvement*

The needs of a client are required by the design teams to develop an optimal solution, however 39% of participants referred to client knowledge as being a limitation to collaboration; decisions made by teams depend on the needs of the client. However, client needs are suggested as challenging to establish, requiring close consultation and therefore putting pressure on the relationship with the client. The contract often states that the clients require to provide their needs in an accurate manner, however in reality, often, suitable client representation is questionable; the representatives do not have the technical skill or experience to explain their needs.

When asked to explain the difficulties dealing with a **client lacking in knowledge**, technical competency as a barrier emerged and affects the social climate as instructions are not clear bringing susceptibility to misunderstanding.

Lack of client knowledge was commonly perceived as resulting in negative consequences toward project level collaboration. A participant used an example and suggested that traditional clients should change the way they think about the project, to focus more on relationships to enable processes that increase trust and create environments for informal information to transfer between teams.

Asymptomatic of the lack of knowledge is the reluctance from clients to use new contracts was related to decisions that **overly control** the project; inflexible and not having the knowledge/experience to make decisions to reduce systemic risks. With experienced clients, needs are clearer, decisions made more efficiently, and teams are given freedom to make less vital project decisions.

Additionally, participants exemplify the importance of client involvement and explain that it brings more trust between teams.

> *'When you don't involve the customer, it ruins the collaborative environment. Usually it's better if you give them more information, they will feel that there is nothing being hidden; The client representatives don't care about the BIMM, they don't really understand it as well' (1, Design and Production, End to End)*

> *'How we represent information the client does not understand and that creates some tension that makes everyone go back and forth, creates inefficiency. This is why experience in terms of people is very important when dealing with the client because it is important to see the client as someone who is not very technical and we cannot give them highly technical answers, and it causes some sort of confusion because there is a complexity caused by this difference. Things are left blurry' (18, Project Manager, Design)*

5.3.2.4.2 Client Trust

Trust emerged in all interviews. In terms of client related trust this emerged as the reason for the over-controlling attitude of a typical client which was suggested in 39% of interviews (7/18).

The over-controlling attitude of the client is evident in the manner the contracts are delegated in some projects. Additionally, controlling the contracts can be perceived as a symbol of client mistrust towards project management as they feel that when the contracts are controlled there can be financial savings. This can be connected to the normative belief that firms want higher profits at the expense of the client resulting in the compromise in the ability to trust the teams.

The knock-on effects of lack of client trust include inconsistent leadership, suboptimal team selection, suboptimal contractual arrangements, poor social climate and therefore higher design/solution modifications. All of which can contribute to increased project cost.

> *'In the typical projects, it's always arguments and old ways of working. It's like that on our side a bit but mainly in the clients, they think that there is a catch, but you*

cannot see it, they think that the building industry is all about making money out of the client. It takes time for example media and schools need to change this kind of mindset. Drawing trust into each other more' (18, Project Manager, Design)

'Sometimes we only recommend the sub-contractors to the client and they will choose, we prefer to make the selection as we usually have more experience working with them and understand what we are looking for' (13, Production Manager, Production)

5.3.2.4.3 Client Organisational Culture

The organisational culture of the client appeared in at least 44% of interviews (8/18). Some participants compared public and private clients and resulted in finding differences in mentality and decision-making that came from the way the client organisation operates. For example, in public clients, **the hierarchy of the organisation** signifies more levels in their organisation structure. This makes decisions passed up the hierarchy therefore slowing down the decision-making time building latency into information transfer; the public client representatives are strictly held accountable for every decision they make.

As compared to a typical private client where cognitive latency is suggested to be less, the focus is more on important decisions and teams are given the freedom to make less important decisions; private firms are more business oriented and want to reduce the time taken to progress. Furthermore, information transfer from the private client was found to be typically faster than the public client.

Furthermore, if the end user is not the client, it was suggested that the **end user has an effect on the client's decision-making process**; the nature of the end product depends on the end user's needs which changes the way decisions are made.

'For example when you look at the private sector where the rent is very high, they are afraid that they might not find the client for the apartment so they have to listen to the end user…In the public project, the rent is so low that they don't have to care about whether the client will take it up because it is in high demand… this for example impacts the attitude of the client…Project has external factors that set the framework for how the client organisation works and then we have to collaborate within that framework' (16, Research and Development, End to End)

'Usually the private client is more efficient in giving information as they can make the decision there and then, however with the public client they are not able to make the decision and have to ask their bosses, so it takes time. The client's hierarchy influences. No one wants to make decisions. The organisation of the client is affecting the project' (12, Design Manager, Design)

5.3.3 The Cultural and Human Aspects

5.3.3.1 Language and Geographical Industry Cultures

Evidence suggests that **language barriers exist** in the Finnish industry in multicultural team environments; this requires a middleman who translates between project participants.

Based on the geographical origination of a firm, cultural barriers were said to arise when collaborating. It is unsure where the attitudes and practices wholly originate from, however, it shows that the expectations in each industry based on geography varies and therefore becomes evident when collaborating across borders. A participant describes the trends in **cultural expectations of processes** with some foreign firms where each different nationality had different expectations, some of which were similar and some of which were very different.

Furthermore, **cultural expectations of behaviour** traits were also suggested to exist especially in the attitude towards addressing problems; in Finland people are expected to be open and honest, however, when dealing with some foreign firms, the problems were being hidden bringing difficulties in collaboration.

It is also suggested that foreign teams can in time, **adapt to the local culture** by understanding the expectations; however, this takes time especially if there are lingual constraints.

> *'Language is a problem as they don't speak Finnish or English. Many people come from Estonia. Usually I have to use someone who can speak in Finnish and Estonian, so it involves translation' (1, Design and Production, End to End)*

> *'In Finland usually people will be open and honest when they are having a problem. That was the biggest difference when dealing with the Belgians, they were hiding problems, more secrets, so that became bigger problems' (9, Production Manager, Production)*

Figure 33 shows a summary of the links made in this section.

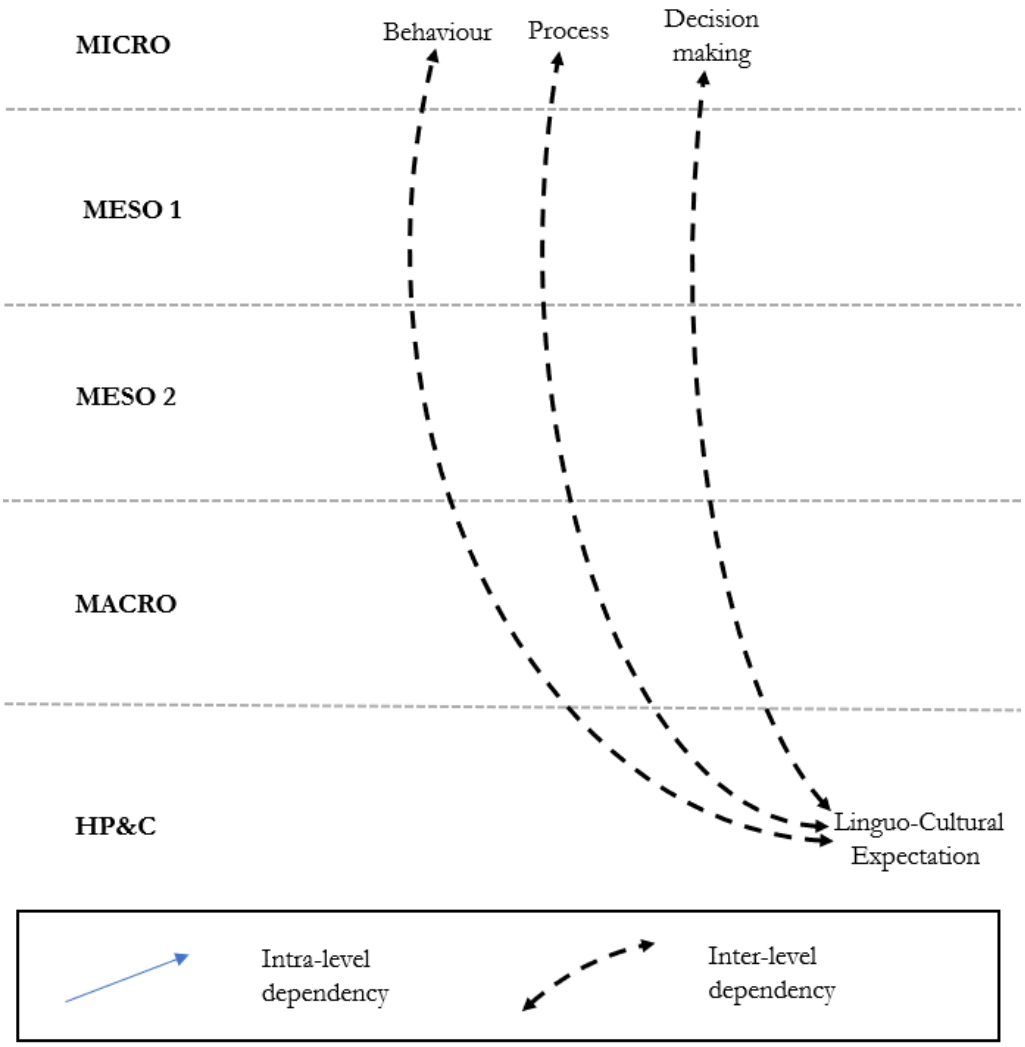


Figure 33: Summary of Section 5.3.3.1

5.3.3.2 Relationships, Trust and Openness

Figure 34 shows a summary of the links made in this section.

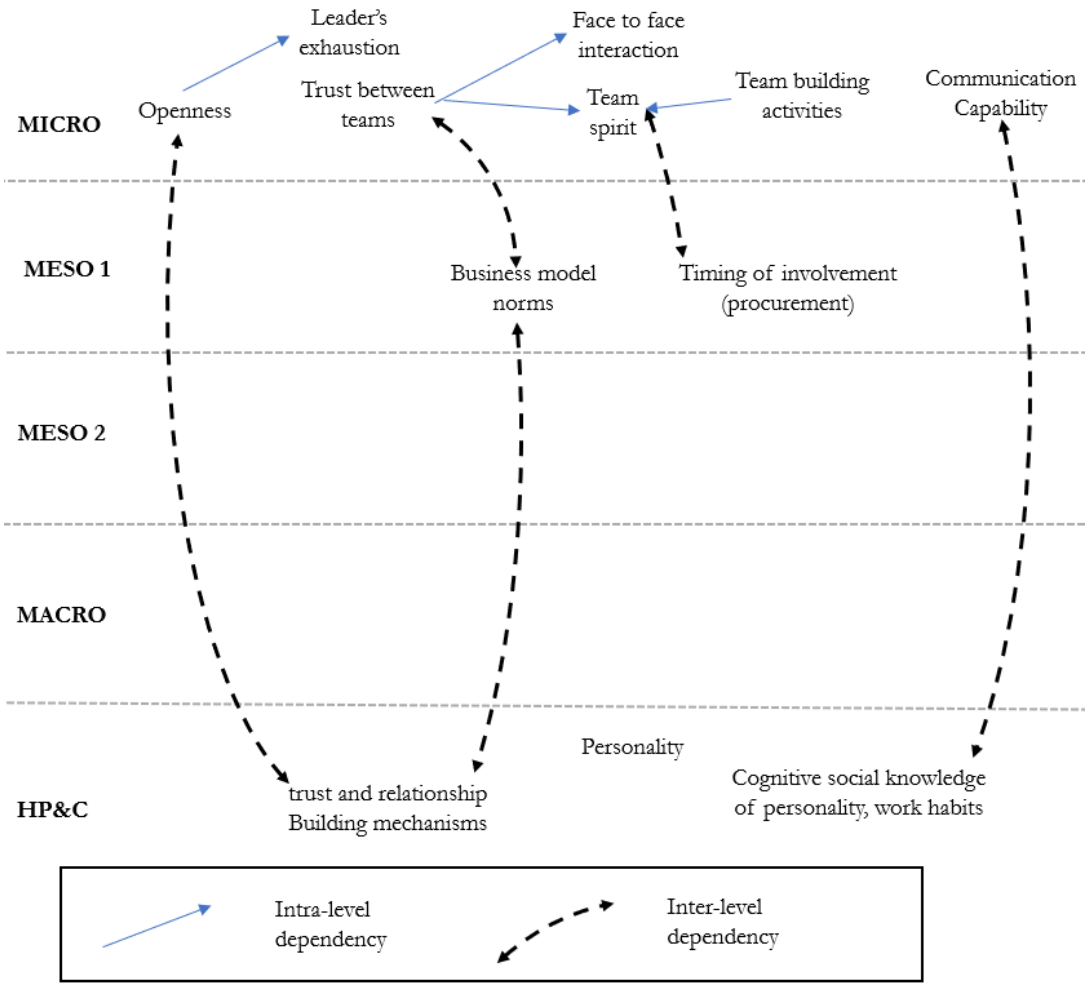


Figure 34: Summary of Section 5.3.3.2

5.3.3.2.1 Relationships and Trust

The human aspects (such as the effect of relationships and team spirit) as compared to the technical aspects (such as digitalisation to improve information flow) are said to be more difficult to develop at the project level. This reiterates the need to understand human centred factors. However, it seems as though **the value of building trust and relationships** is not perceived as significant in industry as processes are centred around tools and people shifted between projects without knowing the effect on the project.

Trust was related to openness between teams and involved knowing team members beyond professional boundaries. Furthermore, more trust and stronger relationships was said to reduce the stress of daily management by the project management as less time and resources need to be put towards following up on activities.

One barrier to building trust is in the normative business model which restricts activities to build trust because of the transient nature of the industry's business model; people change in the project consistently, people are moved between projects, so the social climate is dynamic and ever-changing in the current practice.

'It takes time to build a relationship and build trust, so every project I need to start again because it is new people and we need to start from zero' (14, Production Manager, Production)

'The digitalisation of tools has helped information flow, but the team spirit and the relationships are the hardest part, but I think we have so many good people that they create that kind of atmosphere on site. If the person goes, it changes everything… Hard to build trust between the players, they like doing their own work rather than building trust' (1, Design and Production, End to End)

5.3.3.2.2 Relationship Development

It is claimed that there is significant **benefit in developing team spirit** by investing time early in the project to develop the social climate of the project. People have face to face interaction and therefore there is intangible social understanding and knowledge of one another being gained e.g., knowing the way a person is approached is important to have effective communication. However, the challenge is in the nature of the industry's procurement process being transient meaning that the social climate is dynamic. Therefore, it is suggested that the outside professional boundary interaction should happen throughout the project. More face to face interaction was said to bring less susceptibility to mistrust.

Evidently, building relationships emerged as a potential solution pointed out as critical by more than 50% of participants, some of whom warned that it takes time to build trust.

'Designers come to the project at different stages, similar to the sub-contractors…When they are all onboard…The first meeting should be some soft human interaction where the barriers can break' (12, Design Manager, Design)

'After the informal meetings we can see that something changes from experience. Just shows the importance of developing relationships. When they know each other they can trust each other… That way the project process is smoother even though there might be technical difficulties… How we can develop trust, usually this requires a long time' (2, Schedule Manager, End to End)

5.3.3.3 Personality

Personality emerged in 44% of interviews (8/18). In 'Verstas' meetings, **negative personality traits** of team representatives were also used as an example by two participants (11%) to be a hindrance on the project level leader and other teams because of their over-controlling trait. Personalities are found to be important in developing trust and chemistry between people that form the foundation of human interaction.

A participant mentioned that a personality test would be useful and suggested to look for open people. This was a common opinion; 6 other participants mentioned the preference to work with **an open and agreeable personality** and agreed personality tests would help. The test could be used to decide who can work well in groups.

When speaking about **procuring the right firms**, it was made clear that the organisational traits are not a valid indication of the individual team performance, but it is the people in the organisation's team that need to be assessed.

'Personality of the individual is a big thing. Site managers prefer people with open personality. If we like to work with a person then we work with them even though the price is higher, it is important to know that we can trust the person' (6, Procurement, Production)

'The personalities of the people help avoid the problems or can create it… it is important to get together the people that think in the same way…Trust is crucial' (1, Design and Production, End to End)

'…every company depends on the person to person interaction. It depends on the individual and not the company. Its bias to value a company from one person's experience as if the person changes everything changes' (6, Procurement Manager, Production)

Figure 35 shows a summary of the links made in this section.

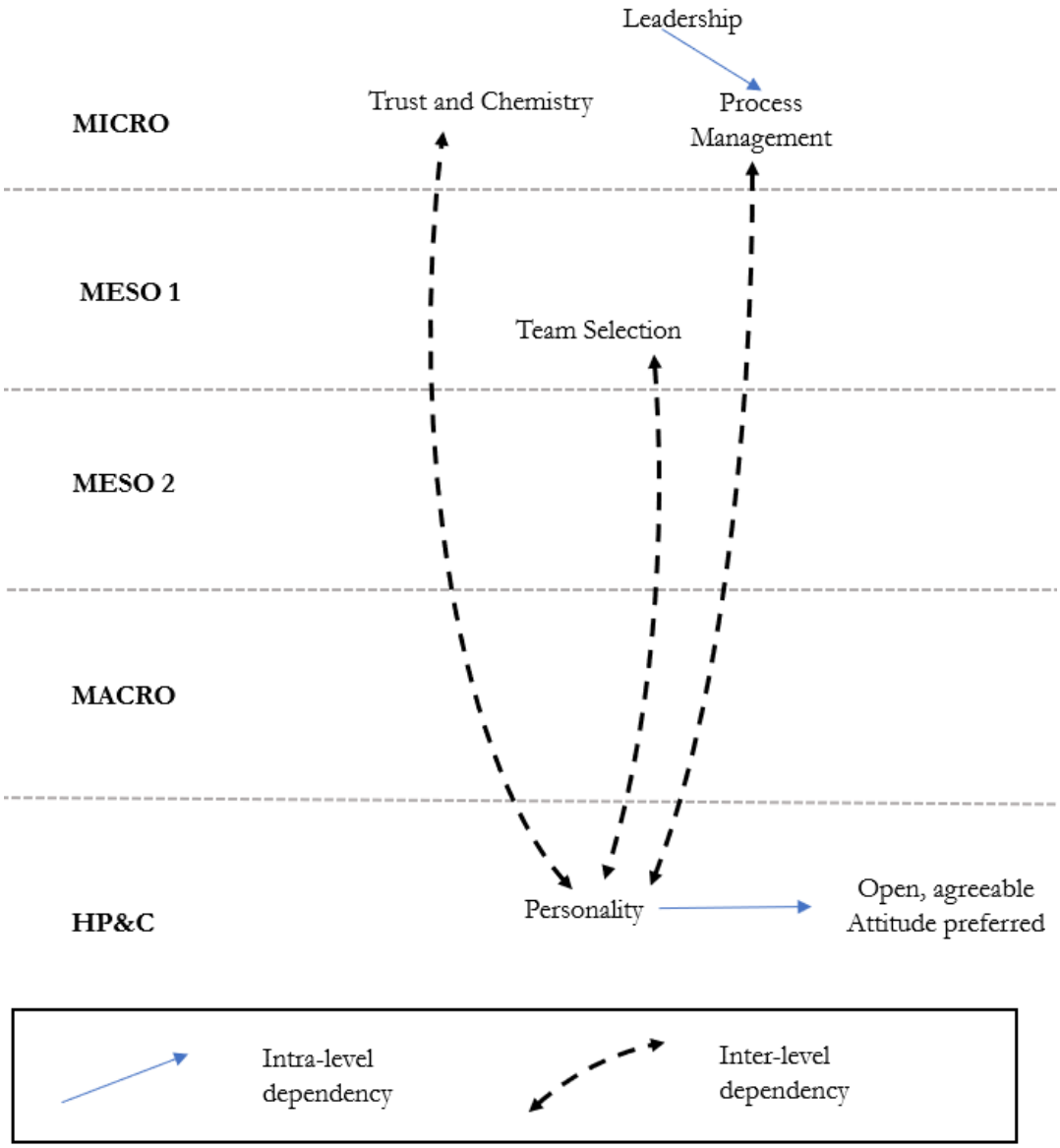


Figure 35: Summary of Section 5.3.3.3

5.3.3.4 Holistic Understanding and Thinking

50% of participants (9/18) made the claim that the designers do not understand production or vice versa suggesting a lack of holistic understanding. Holistic understanding is different from holistic thinking; the understanding is if the practitioner has the capability to think holistically whereas holistic thinking is using the understanding. A split between **design and production**, reducing with increased designer site experience emerges where production participants say that designers don't have production knowledge and vice versa.

The fundamental difficulty of understanding the end to end process of construction is suggested to lie in **the education system's** siloed nature where design and production professionals are separated, therefore going against a holistic understanding.

The Alliance **contracts** were linked to motivating holistic thinking, by shared risk and reward, reducing the fear of liability, teams can go beyond their formal role to ensure that their solution fits the overall solution.

> *'Alliance project contracts seem to force them to think more holistically about the whole project process, to think about what makes the client gain more value' (2, Schedule Management, End to End)*

> *'Many of the designers do not understand production and production people also don't understand design…The education system in Finland splits people in terms of production and design…Site people can usually blame the designers…' (15, Production Manager, Production)*

Figure 36 shows a summary of the links made in this section.

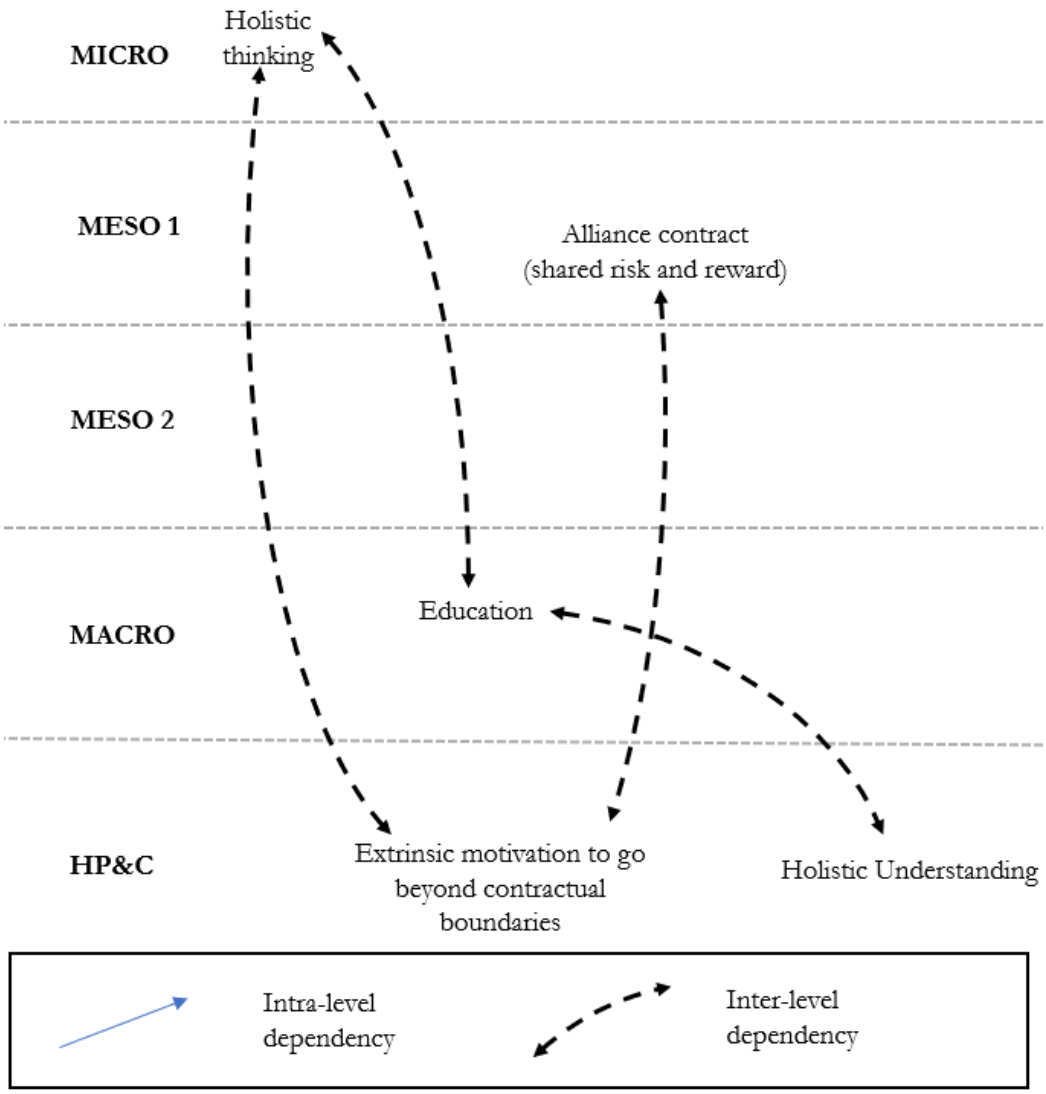


Figure 36: Summary of Section 5.3.3.4

5.4 Study 2 - Norway

The following section focuses on the data collected from a number of firms in Norway. Similar to Section 5.3.1, Figure 37 and Figure 38 show the thematic interactions. The colour of the nodes and arrows represent the strength of coverage in the empirical data. Data was collected from a number of firms in Norway that operate at different parts of the design and construction process. The contractors were large hierarchical firms representing the largest private organisations. The consultant was one of the big 6 Norwegian multidisciplinary design firms with a flatter hierarchy than the contractors. The public client is a large organisation appointed by the government to enhance the implementation of digitalisation in the local industry. The Professional Organisation (PO) is responsible for standardisation of BIM and is involved in certifying practitioners on the use of BIM. The Project Management (PM) firm differed from the other firms as its origin is the North of Norway. The firm has a flat hierarchy (similar to Study 1 PM firm) and is involved in innovative methods to manage process management by embedding lean principles into their firm's identity. Table 17 shows the structure of this section in reference to the relevant themes analysed.

Table 17: Overview of Themes Analysed from Study 2

Section	Theme
5.4.2.1	Contracts
5.4.2.1.1	Win-Lose Mentality
5.4.2.1.2	Contract Effect on Collaboration Environment
5.4.2.1.3	Business Model and Innovation in the Project Lifecycle
5.4.2.1.4	Team Selection (Procurement)
5.4.2.2	Client
5.4.2.2.1	Client Knowledge and Involvement
5.4.2.2.2	The Relationship with the Client
5.4.2.3	Change Management
5.4.2.4	Organisational Culture
5.4.2.5	Data Exchange and Process Management
5.4.2.5.1	Communication
5.4.2.5.2	Definition of Information
5.4.2.5.3	Loss of Useable or Quality of Information
5.4.2.5.4	Strategy Definition
5.4.2.5.5	Lean Information
5.4.2.5.6	Holistic Understanding and Thinking
5.4.2.5.7	Virtual Design and Construction (VDC)
5.4.2.5.8	Technical Competency
5.4.3.1	Attitudes and Belief
5.4.3.2	Decision-making
5.4.3.3	Holistic Understanding and Thinking
5.4.3.4	Local Industry Culture
5.4.3.5	Motivation
5.4.3.6	Openness
5.4.3.7	Relationships
5.4.3.8	Trust
5.4.3.9	Personality

5.4.1 Thematic Structure and Interactions

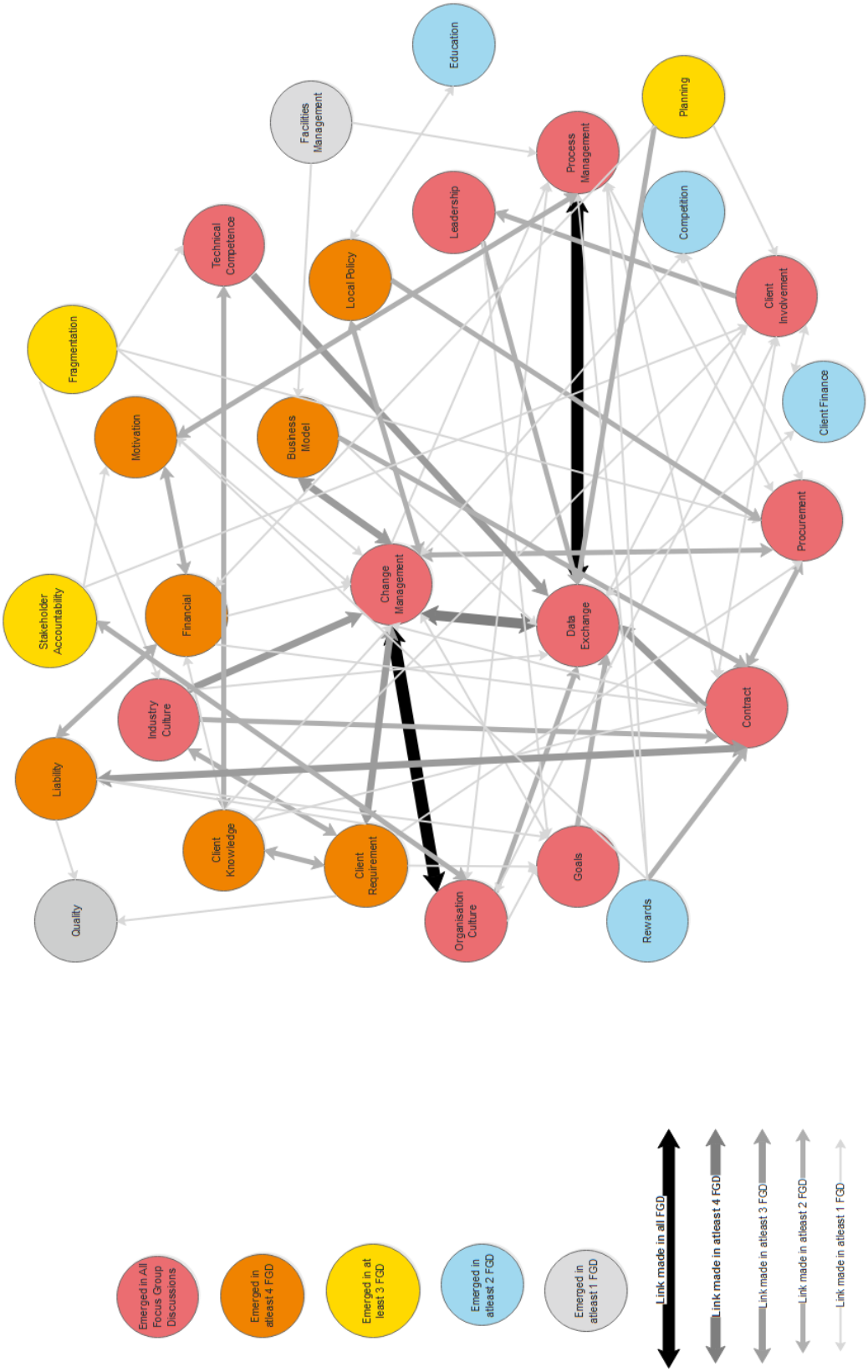


Figure 37: Thematic Interaction of Project Related Factors in Study 2

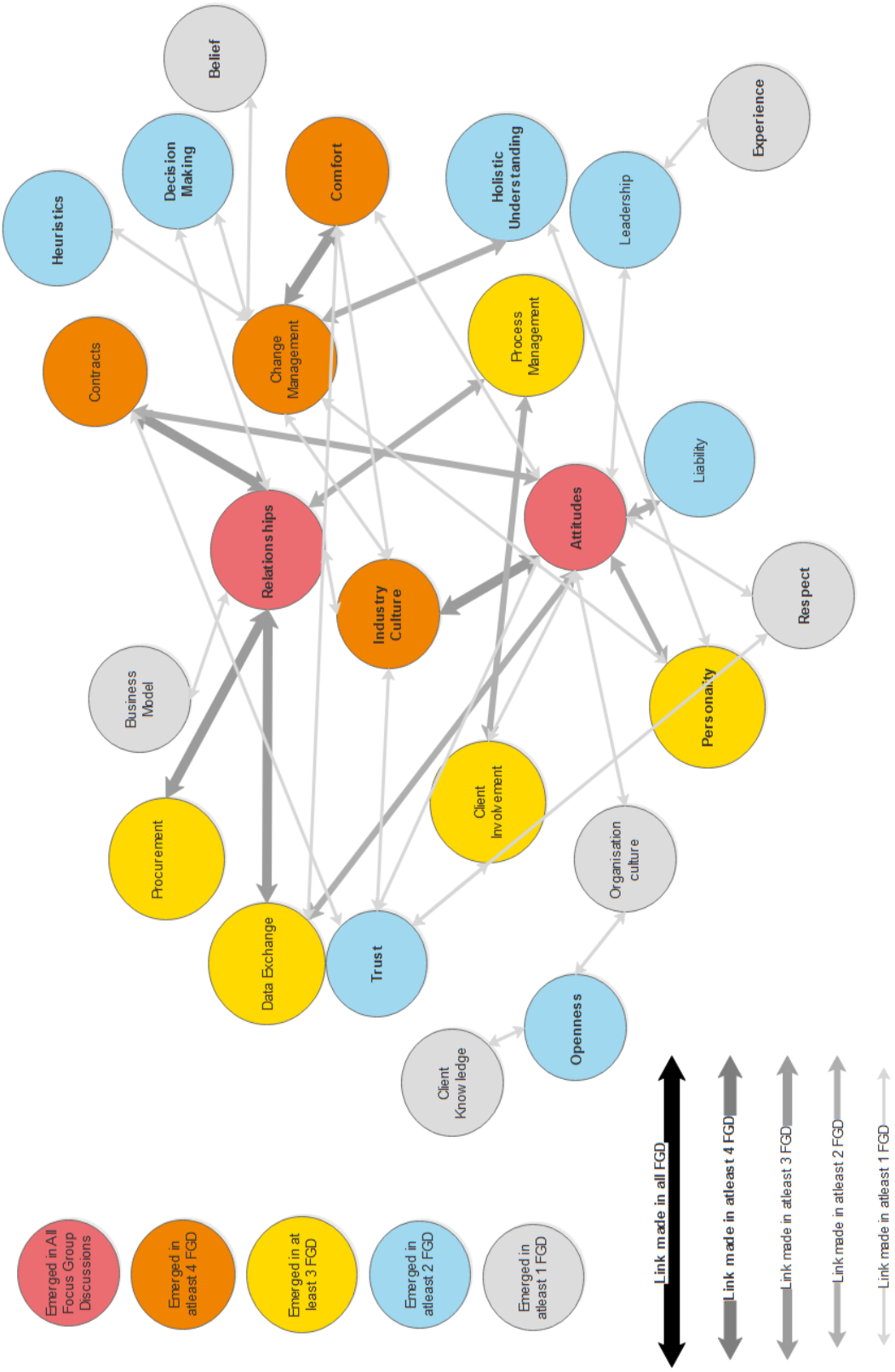


Figure 38: Thematic Interactions Between Project and Human Factors in Study 2

5.4.2 Narratives Centred Around Project Based Themes

5.4.2.1 Contracts

Design consultants explained **the difficulty of defining data in contracts** as a result to technological advances e.g., BIMM (Building Information Management Modelling) as compared to 2D CAD where drawings were outputs. With BIMM, defining the types of models and how information is exchanged between teams is more complex (further evidence in Section 5.4.2.5.2). A contractor and Professional Organisation (PO) also raised that in many construction projects the contracts stipulate output still in the form of drawings. The use of drawings as outputs in contracts shows to be inhibiting real change as it makes people fall back to what is normal to them.

> *'very often in projects they are translating that into paper drawings, we take all the value out of the product and so I think often they don't understand how we operate and what kind of value we are operating with' (Consultant)*

> *'…for a long time, you are paid for the construction drawings, so the production drawings. If you are not paid for the right output, then the need to change is gone…' (Professional Organisation)*

5.4.2.1.1 Win-Lose Mentality

Traditional contracts are suggested to be inhibiting collaboration by creating fragmented mentalities. The difficulty in **changing the standard form of contracts** is found to be as a result of its long history of use; it is believed to be normative.

Evidence suggests that the mentality resulting from liability-based contracts results in a **win-lose mentality** related to the blame culture. When discussing the way clients manage the finance of the project, **liability and blame emerge**. Contracts inflict the liabilities and an indirect lack of motivation to innovate as the firm is paid for output and not being innovative.

The consultants called for **changes in the traditional contracts**, business and revenue models as a result of the liability driven mentalities in the industry. The contracts are currently overly focused on expenses with respect to material or time, but participants explain that their intangible, immeasurable costs in a project as well. There is need to shift towards what they call 'value-based contracting'.

When asked for an example of a client the consultants do value-based work with, it was clear that the initiative to innovate was brought about from the consultant. They added that there was no incentive to innovate as there is no reward for it (**lack of rewards)**, the contract was liability based. As their relationship with the client was of a good nature, the consultant could be trusted to make changes to the technical process which resulted in automation of a manual process resulting in saved cost and time. In this example, the client – consultant relationship supersedes the influence of the normative contracts on the mentality.

Additionally, the **limitations of the contract to incentivise collaboration** emerges as a result of discussing how the contract mentions collaboration. It is enforced, which is expressed

as ineffective, as the expectations are ambiguous. Based on the data collected, it is evident that it is not necessarily true that any group of teams can collaborate, however, the contracts demand collaboration.

On the other hand, the PO uses Integrated Project Delivery (IPD) as an example to incentivise collaboration using **shared risk and rewards** as compared to the traditional approach and how it affects human behaviour. The shared risk and rewards are suggested to give freedom to practitioners to venture outside their traditional boundaries as a positive contribution to the project is also a positive contribution to their firm.

> *'In an IPD they decide that we need to have a collaborative environment where people are not only not afraid of getting burned but there are incentives to improve collaboration to go outside the traditional boundaries. So I think if you start with a client saying we want this, we will monitor you and if you don't meet it you will get punished, then you will never really have a good collaborative environment' (Professional Organisation)*

> *'The contracts often say you shall collaborate, but if the collaborating environment isn't there, it doesn't matter what the contract says…You can't force the collaboration in a good way. I believe that some or all contracts say that, you're supposed to collaborate with the other disciplines and the client and the user' (Professional Organisation)*

Figure 39 shows a summary of the links made in this section.

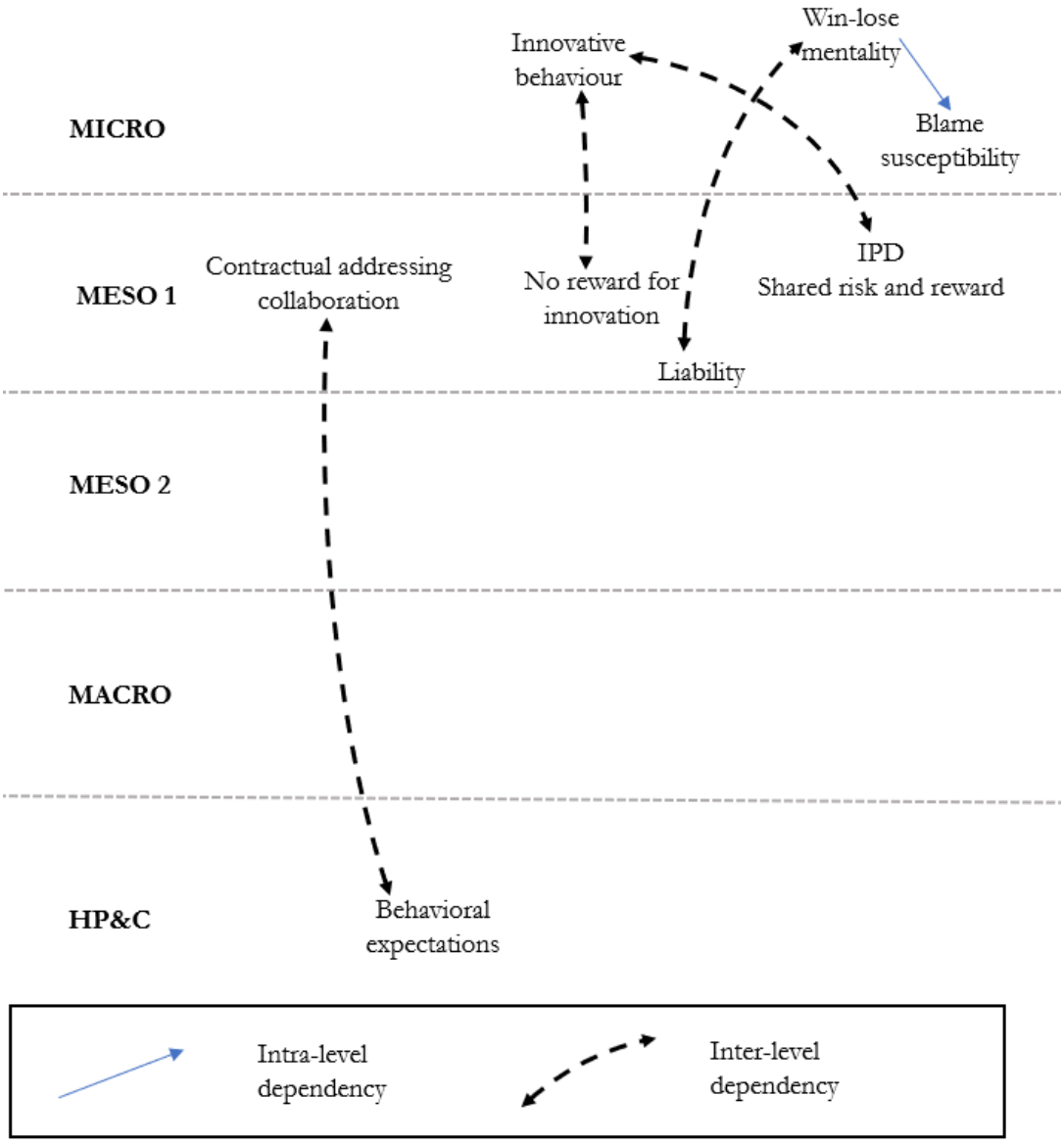


Figure 39: Summary of Section 5.4.2.1.1

5.4.2.1.2 Contract Effect on Collaboration Environment

A contractor explains the **effect of the contract on the nature of dialogue** between project teams and the client, suggesting that the D&B contracts are open to more dialogue brought about by more transparency. The transparency is linked to increased ability to develop trust between contractors and consultants.

Additionally, regarding the D&B contract, the Project Management (PM) discussion mentioned that **production knowledge needs to be brought to the design table** to smoothen production. This depends on the procurement mechanism and how much iterative transfer is allowed e.g., whether the procurement facilitates early involvement of the contractor.

'Standard' Contracts emerged in the discussion with consultants; there are **fundamental problems with the standard contracts** relating to liability and collaboration. Inevitably it came down to challenging the status quo and related this to businesses having short term goals.

When asked to reiterate the link between contracts and **incentivising collaborative attitudes** at the project level, client factors emerge (further discussed in Section 5.4.2.2). The client arises as a critical decision maker in devising the nature of contracts utilised. Furthermore, the attitude of the client also emerges as an important factor to consider the views of the knowledgeable and experienced consultants, boiling down to the trust between them.

> *'…the clients can decide how are we going to acquire this project…it's also a clear decision and strategy based and they decide actually, if they have a more value based design or project with collaboration or IPD contracts then you incentivise people to think differently and if you don't have that as a contractual foundation or monetary incentive then it is really challenging. If you have a client with an open mind and traditional way of working, you can challenge the client and say did you know, or do you know. And tell them you can have a much better product if you do this, thinking a few steps ahead' (Consultants)*

Figure 40 shows a summary of the links made in this section.

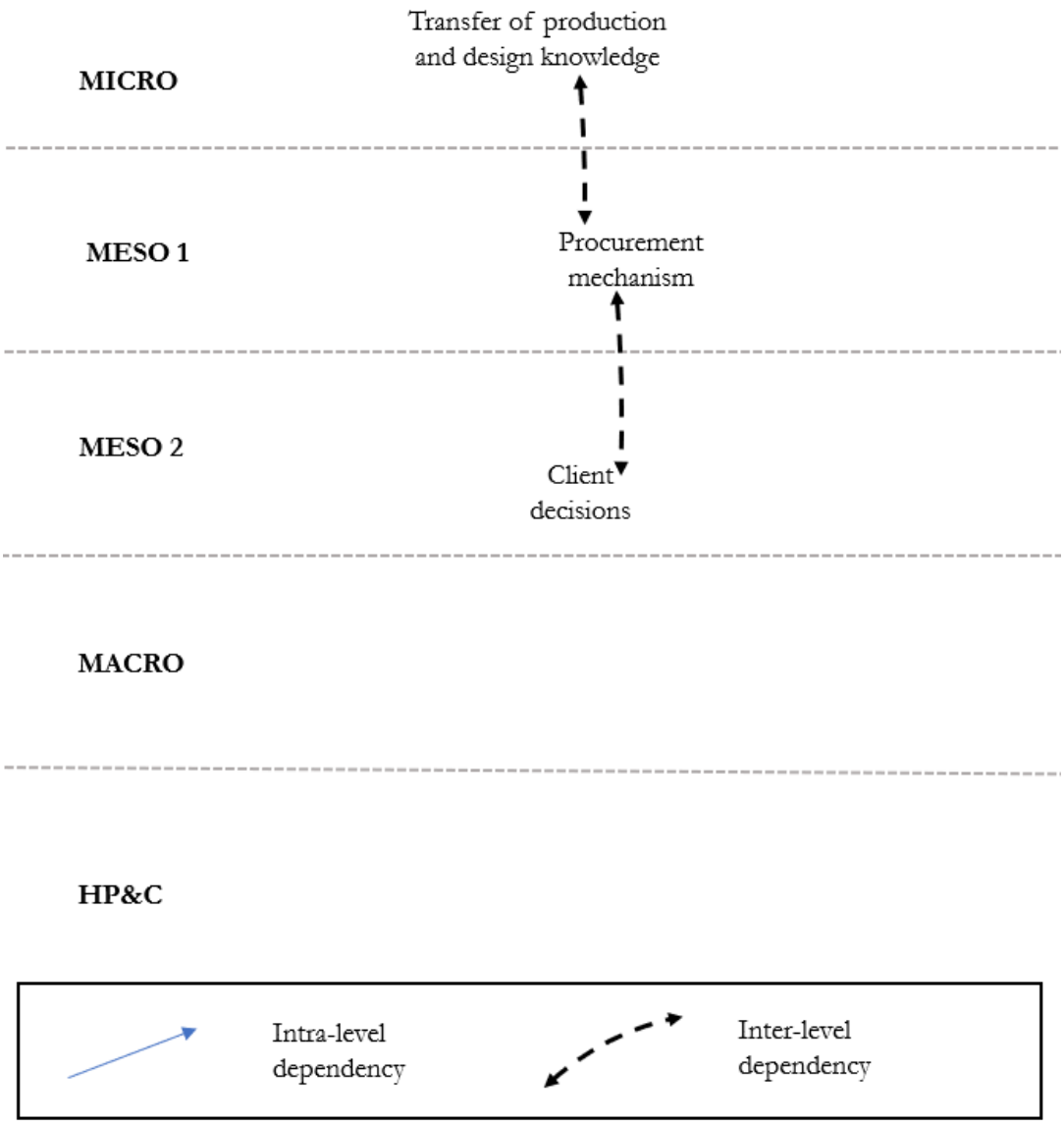


Figure 40: Summary of Section 5.4.2.1.2

5.4.2.1.3 Business Model and Innovation in the Project Lifecycle

An example case of two different business models is used to show the **effect on human behaviour**. The client's firm procures teams based on two different routes, D&B and DBB. The client explains that the D&B procurement route is typically used for simpler projects which the client can define needs for at a higher level of accuracy. On the other hand, the DBB procurement route is more suitable for more complex projects which the client cannot define their needs or know how to fulfil them. When probed, the lack of effect of design teams on lifecycle innovation was put across in a rhetorical fashion; innovation beyond their involvement is lacking e.g., in facilities management.

In DBB projects, the designers are reimbursable by the hour as compared to fixed price in D&B. However, when comparing the quality of the BIMM for FM DBB is suggested to perform better. In D&B, the designers' focus is on structuring information to construct the building, they are not incentivised to think beyond that. However, in DBB, the client can cooperate closer with the designer and this allows for a FM suitable structured model, although it is still a challenge as the designers do not seem to have that level of foresight.

A consultant also explained the **need for the business model to change** as there is limited innovation possibilities within the design phase of a project, to expand over a larger part of the lifecycle means there needs to be changes to the business model. This view was also supported by contractors and the public client.

A contractor expresses **the misalignment of innovation and the business model**. When the participants were asked how they show the value of innovation when asking for funding or finding clients it is inevitable that showing short term success of innovation is challenging suggesting the misalignment.

It can be argued that the misalignment of innovation and the business model is also evident from how success is measured. In current ways of measuring on a project to project design and construction focus (driven by the business model) benefits are unclear. Evidence of the **misalignment of the business model** and nature of innovation is evident when a business takes control of a larger part of the construction process resulting in higher profits. Getting control of a larger part of the lifecycle to engage in more substantial innovation activities was also mentioned by one contractor, exemplifying the positive effects on innovation using internal asset development which is more profitable to the company.

The public client who is involved in the whole building lifecycle from start to finish explained that the business model makes the **BIM process belong to different businesses** making collaboration vital. Although a limitation emerged from the discussion with the consultants where it was suggested that when one business has more of the project lifecycle this can enable internal loss of control and authority.

The PM participants put across their opinion when discussing the optimal way to set up a construction project in relation to collaboration, elements from the Swedish form of partnering emerged; economic openness, common targets, partnering between firms all of which are expressed to improve the social climate.

> *'…from the front until that point, disregard maintenance and operation, still project costs, if you see what percentage the design is into that equation. You can be twice as good, still won't contribute substantially. You can be just as clever but the cost of 4 years 5 years development with construction then design fee is so little so how can make a revolution from the design point of view?' (Public client)*

> *'we are working to over sophisticate too little part of the value chain, it doesn't matter, because your contribution to the end result is so limited, so the challenge is how to contribute more… the only way is to get involved in other parts of the lifecycle' (Consultant)*

> *'We are also going into developing our own properties to sell so business to consumer directly rather than to a professional client, so more like an investment, this way we can decide how to innovate and when' (Contractor)*

Figure 41 shows a summary of the links made in this section.

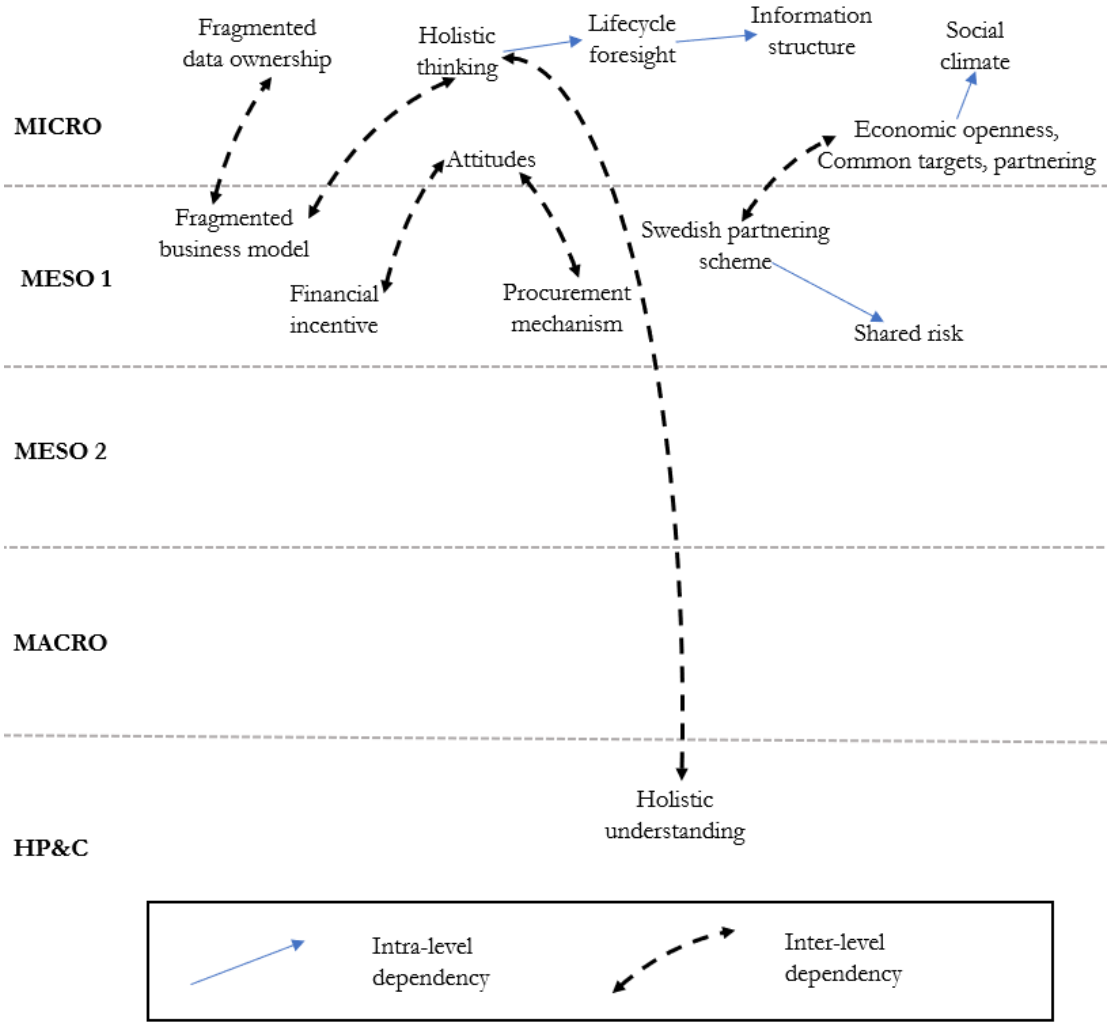


Figure 41: Summary of Section 5.4.2.1.3

5.4.2.1.4 Team Selection (Procurement)

The public client was asked what they look for to select the right teams for the project. They use four variables; price, construction experience, technical ability and their practicality of solutions.

One of the challenges raised by the public client is the **discrepancy of the data provided at the tender stage and the reality when selected**. For example, the companies can provide very good CVs but when the contract begins, the people who are allocated do not reflect the documentation provided, this affects the client trust and has a knock-on effect on the social climate.

The discussion with the PO about procurement in public clients resulted in the link to local policy. The participants explained the positive value of having teams that already have a working relationship to collaborate repeatedly. However, EU regulations (local policy) stipulate that all projects are to be put across on public tender most likely resulting in new teams with no previous relationship needing to break the barrier to collaborate. This is where the value of organisations that standardise was brought up, explaining that the process can be standardised to make exchanges smoother. However, the standards are typically for technical purposes and not social or psychological in any way.

The PM explains a common situation where the positive collaborative relationship between their firm and the client is not replicated throughout the supply chain. The need for combinations of procurement strategies is suggested based on the nature of work.

> *'So, when it comes to selection of teams, the contractors will partner up with some engineering companies that will provide the most experienced & beautiful CVs. But when we start up, it turns out that we don't necessarily get those people and they don't have the experience that they promised that they have. So, we are struggling with the mentality and the knowledge... As part of the tender process, the engineering group have to provide this in the tender. How they see it will be carried it out, whether they are creative, conservative, whether they have a good idea and understand the problem, that is a critical part of the evaluation....' (Public Client)*

Figure 42 shows a summary of the links made in this section.

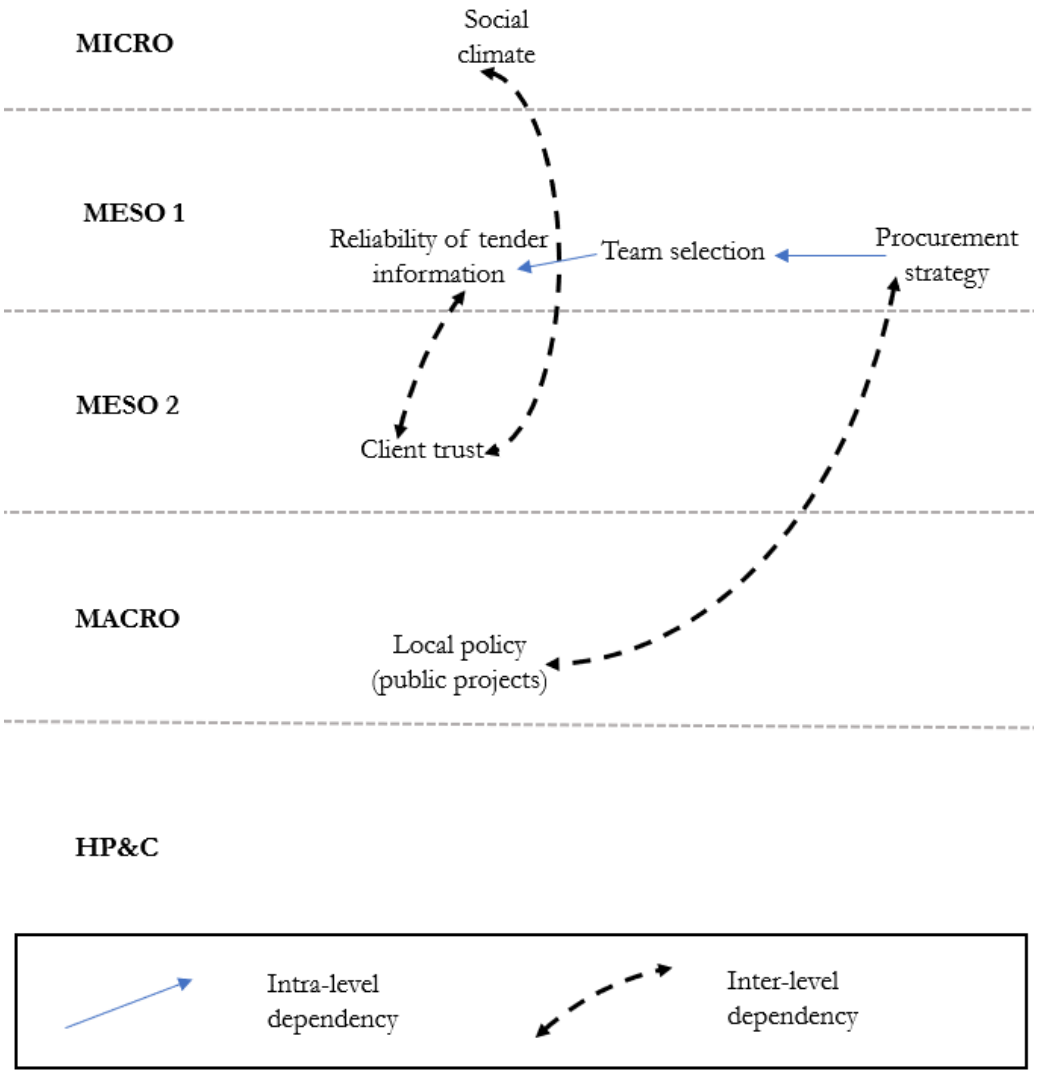


Figure 42: Summary of Section 5.4.2.1.4

5.4.2.2 Client

Figure 43 shows a summary of the links made in this section.

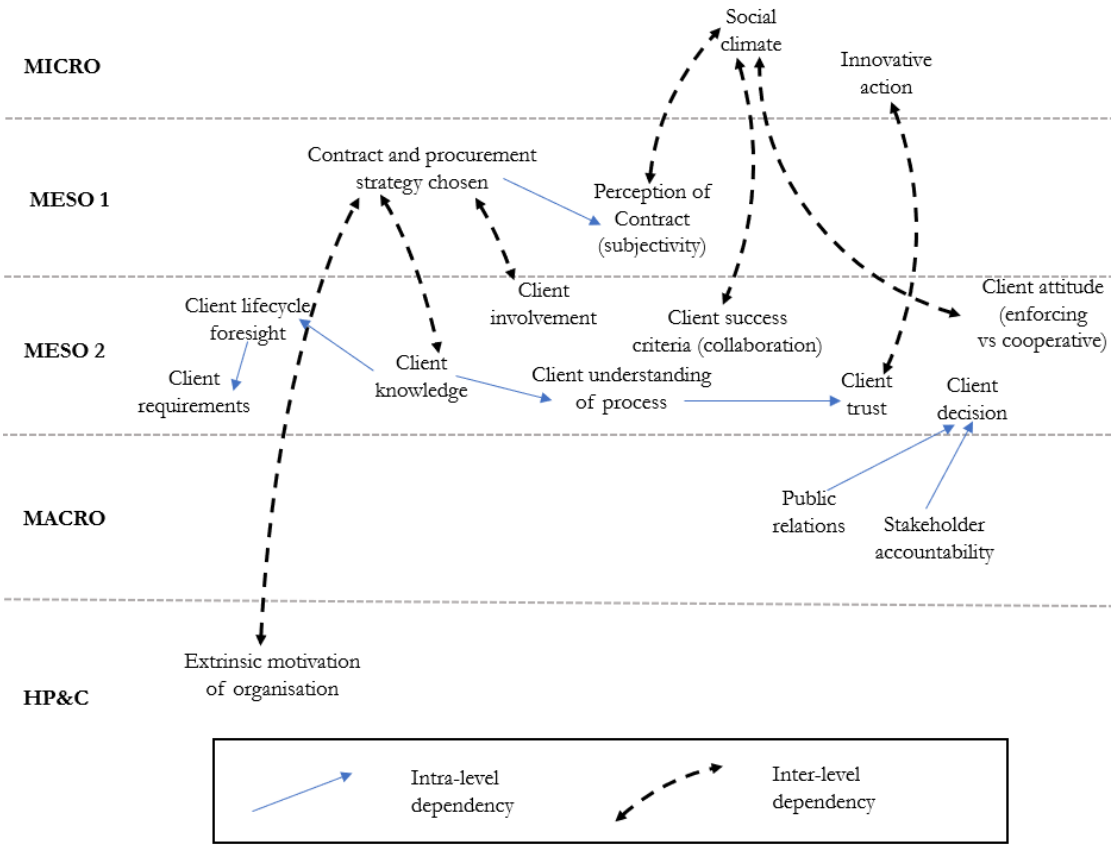


Figure 43: Summary of Section 5.4.2.2

5.4.2.2.1 Client Knowledge and Involvement

The knowledge of the client emerges in all focus groups except with the contractors both of whom focused more on the requirements of the client. The **importance of client knowledge** in creating a collaborative environment emerges in discussion with the PO using a highly knowledgeable and experienced client as an example; creating a collaborative environment is a success criteria.

Regarding client understanding of the construction process, keeping in mind that clients are heavily involved in developing the contracts; consultants explain that it is testing the technical knowledge of the client when considering BIM, if they have contracts that ask for paper based output, this is taking the value out of the innovative action. Furthermore, it also shows that the clients do not really know the capability of the contracted firms.

Client knowledge was related to contracts as mentioned in Section 5.4.2.1.2. Consultants mention that the client needs to understand that project costs which are not solely by material and time. The number of clients who perceive project costs this way is still very low when comparing all the clients they deal with. Furthermore, the client **needs to understand the process** of design and construction to be able to trust teams enough to allow for early investment into innovative activities.

The discussion lead to a consultant highlighting the need to shift to value based procurement limited by the clients' ability to provide requirements as required by standards and definition of what is needed later on in the project lifecycle (lifecycle foresight); clients do not have the skill to complete UK PAS employer requirements on their own.

The public client also explains that there is a lack of understanding of what is needed by the client, what is needed is changing consistently throughout the project.

> *'there is a hotel chain, the clients know that the success criteria involves creating a collaborative project, so it really depends on how much the client knows about the project and the industry' (Professional Organisation)*

> *'…there is this new ISO standard from the UK PAS documents that need employer requirements. But there is not that skill in the clients and there is not enough maturity in the clients to shift to value based. For instance, you have clash detection it has a definite value, you have the creating the 4D model for the contractor to use, lean construction methods. The cost side of models, but also the processes when you end up with the client's ownership of information to save money maybe there is a lot of value, how to maintain the buildings and maintenance protocols, In the sense where everything is more or less automatic.' (Consultant)*

5.4.2.2.2 The Relationship with the Client

The importance of the open **relationship with the client** is brought out as a result of discussing the need for the client to understand early investment in processes that could add value throughout the design and construction phase. This is suggested to be dependent on **trust** between client and consultants.

The way the client gets involved was linked to the contractual setup of the project. The public client explains that when they choose to use a DBB procurement route, the consultants are forced to collaborate with the client as the contract is with the client directly. Additionally, the relationship is important because the lacking capacity of the client to check models (e.g., to ensure models are created suitable for FM) require them to trust the consultants.

On the other hand, a discussion with a contractor (referring to the same public client) explained that often the public client's information delivery requirements are too technical that many employees don't understand it.

The **over-controlling attitude in the client representation** was symptomatic of what constitutes to the nature of the client involvement, this involvement is affected e.g., if an external firm is representing the client.

A contractor mentions the need to collaborate with the client in DBB as the changes go through the clients to the designer. The discussion moves towards the negative effects of an over-controlling client on the social climate and is related to the fixed pricing when working with contractors in a DBB procurement route. The discussion moved towards questioning the enablers of positive collaboration and resulted in discussing the D&B projects with client organisations enabling more trust by bringing more respect and freedom to the main contractor.

The discussion with the PO regarding client involvement brought about an example of a public project which was forced to shut down due to over-expenditure. A number of themes emerge as a result of the **client's decision** of a fixed price contract e.g., their enforcing attitude was bringing poor collaboration because of lack of flexibility and an enforcing attitude.

The project was then restarted with a new business model which incentivised collaboration which was seen by a more flexible procurement route and a complete change in client attitude (going from enforcing to cooperative). The procurement strategy defined by the client impacts the client's behaviour suggesting a relation between financial management and client behaviour. The example further reiterates the link made between the **contractual strategy (organisational extrinsic motivation) on human behaviour**. The client's behaviour is also shown to have a knock-on effect on the social climate at the project level. The discussion with the PO moved towards questioning client behaviour and resulted in the **organisational culture of the client** organisation. Stakeholder accountability in the form of reporting structures and public relation (PR) emerged as external factors that affect the way individuals working for the client are constrained in making decisions.

A contractor raises inadequate perceptions of quality as a cultural problem using an example of a public client; physical quality is often misinterpreted for value. Additionally, the contractor explains the client's use of the contract to make decisions as being an example difference between private and public clients; the same contract can be interpreted in multiple ways (contractual subjectivity).

> *'it also involves the dialogue between you and the client…You also have certain rules… Explain to the client about investing more time in the beginning to start the project well so that the opportunities down the road are much more. There are plenty of project examples where the client puts the brakes in the beginning and then the project costs escalate when you introduce changes too late in the project. Its forms a lot of chaos…It's the lack of the holistic view and to have the clients take in ownership' (Consultant)*

> *'In Norway you have public clients building a lot of projects, so if the project manager the project has a reporting structure, you lose faith if you have done something wrong, and everything is about who is to blame and obviously this is also reflected in the contracts, with the public clients, especially if a project goes wrong then PR disaster, it blows up in the media…The one person who was central to the whole project has to go then you are getting rid of any potential of learning about that. Every mechanism is set up to find the blame and to get rid of them, then you have solved it, Goal in the public is more about satisfying the public' (Professional Organisation)*

> *'... depends on how you are following the contract and how to read it. Difference between public and private? I think my experience is that the public clients are much harder and difficult to work with. Because the railway and road authorities they are kings, they are top of the hill, they know best and are very detailed in how they are running their projects, no trust between clients and contractors' (Contractor)*

5.4.2.3 Change Management

The consultants were asked to describe the mentality in the industry towards using digitalisation:

> *'…somewhere in between thinking that they are the only note in the symphony, or they are one note in the symphony' (Consultant)*

A contractor explains **the effect of technological change** (e.g., BIM) is partly in the ability to make changes earlier by the use of clash detection, reducing the impact of design modifications on site, bringing less possibility for interruptions of social climate on site.

The public client organisation is involved in assisting the Norwegian government to serve as an example to encourage changes driven by digitalisation. **Idealised change**; the client claims that the way data is used and delivered requires changes in the way people think. The claim was related to the **business model and the misalignment of innovation** in the project lifecycle. This was a common view from the consultants and the public client. However, the public client expresses their frustration towards the design firms by explaining that the way information is delivered does not suit the other stages in the project lifecycle e.g., facilities management; reiterating the need for changes in mentality regarding information delivery. The complexity brought about by the systemic nature of the industry; even though changes in business models are being experimented, part of the problem inherently exists within the client's ability to express technical needs. The mentality towards siloed working is restricting the innovative potential of BIM across the lifecycle, where **measuring success** is a barrier. Furthermore, a contractor also brings up the **lack of client knowledge** in knowing what they need by raising impractical strategies, there is a dependence on the client needs.

The data suggests that **natural changes in the market** are forcing consultancy firms to innovate within the capability of their operations, which are restricted. To contractors, there has not been any significant development of technology in the production phase, data is still being processed traditionally. The comparison of these perspectives suggests that there is an inequality in innovative action between design and production. Possibly reasoning was in the **lack of comfort in changing routines** resulting in changes in the presentation of information which has posed as a barrier towards changing work methods. Expectations are the same and developed over a long history of normative thinking.

> *'dynamic information presentations vs static – AEC industry is used to having the static ways, the reinforcement bars manufacturers, they want the bending list in the same way as they have been getting it for the last 30 years. Earlier in the ink drawing, you need to do it that way and they don't like change. It's all about what they are used to doing and the comfort that they have with that way of information being presented... Instead they made their own list in excel after all of this work so just reworking to make it look the way they want it to.... It's not easy to change the way people work. If the output is not looking the same way, then there is a problem and the people don't want to do it.' (Contractor)*

> *'Making the BIMM more valuable requires a relook at the way people think of BIM' (Public Client)*

'Nearly no development with contractors for the last 10 to 15 years. So it's about getting focus on working with the technology and the situation around us has to be put people into it and time to do it regarding competence and how the business is set up… even the tools that our engineers use has not been developing' (Contractor)

Figure 44 shows a summary of the links made in this section.

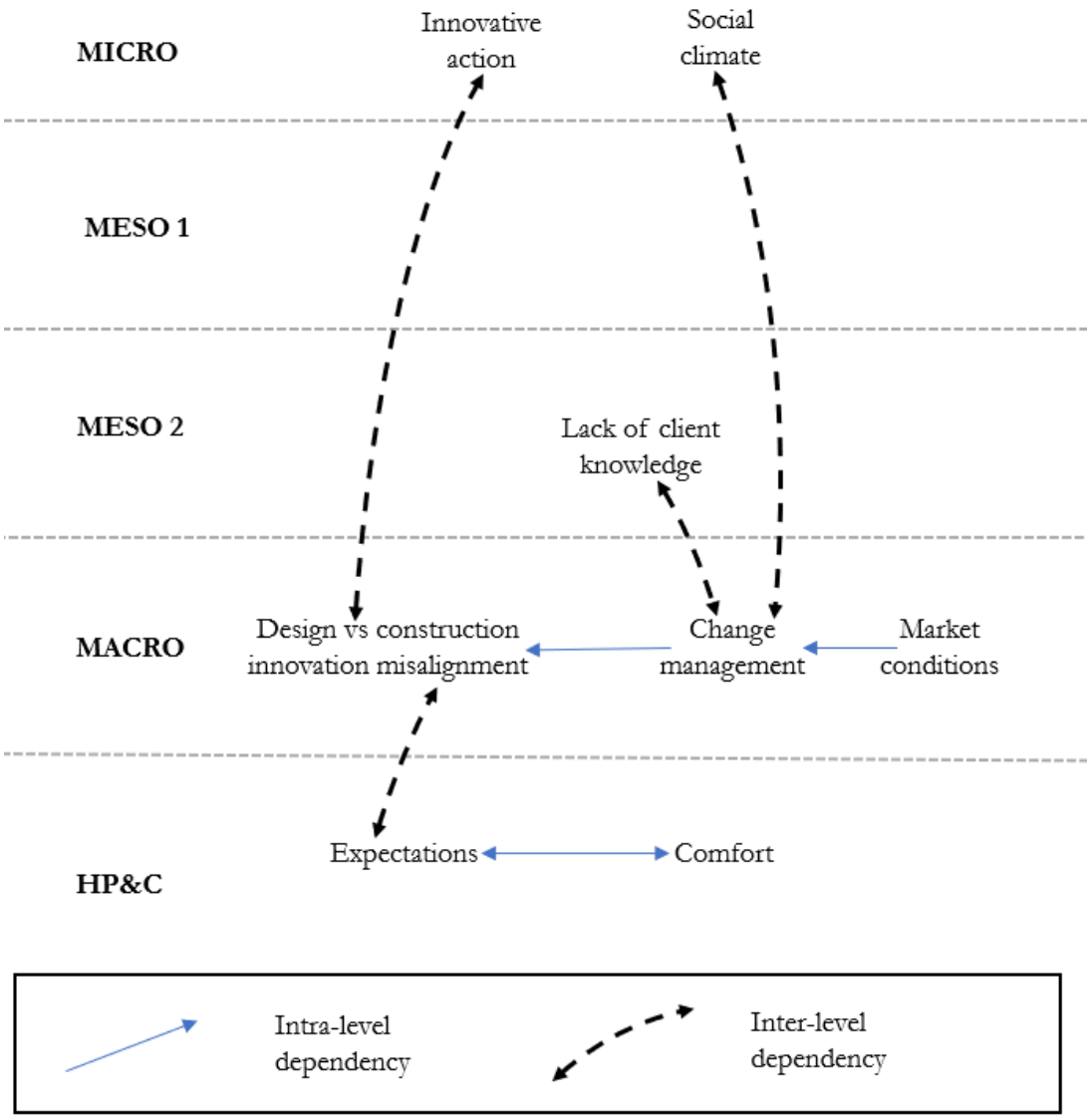


Figure 44: Summary of Section 5.4.2.3

5.4.2.4 Organisational Culture

The difference in mentality between the lower/middle management and the higher-level management (decision makers) was found to be a critical barrier towards digitalisation in contracting firms in Norway. From a discussion with the first contractor firm, even though demands are made to digitalise, the differences in perspective in the **organisational hierarchy** is evidently stagnating changes in delivery; middle management want new tools to digitalise as needed by industry, however, higher level management see it as a high risk investment and do not have the same understanding as the middle management. This signifies that there is need for intra-

organisational collaboration through the hierarchy regarding digitalisation. Therefore, **technical competency of higher-level management** in understanding the risks are a barrier to intra-organisational investment to enable effective digitalisation; digitalisation is still commonly perceived by decision makers as the same as IT hardware.

Similarly, the second contractor puts forward the experience of presenting the internal needs to higher level management who control the resources to make changes; the challenge is that the higher level management want to see short-term benefits but it is challenging to provide certain benefits, it has to be a long-term investment.

It can be noted that the perception of digitalisation should be as an investment rather than a cost is necessary to bring about changes to organisational culture to suit digitalisation and therefore information delivery. The PO suggested that evidence of the benefits of digitalisation need to be completely shown to ensure that the investment is worth it. From the view of the public client, the discrepancy in perspective towards digitalisation between the decision makers and the 'doers' is also evident; top managers are promising digitalisation but when dealing with the middle managers, they are not getting the support that they need to digitalise.

A BIM manager from a contracting firm explains the **interactions between the various organisational cultures** and links this to the motivational differences in the engineering and management parts of the company's workforce. The participant calls for increased transparency and openness in communicating.

> *'Bottom up selling is going on in the companies, where we have to sell it to our management. Because we don't understand that it will cost, I try to find out how we should work in ten years. There are no benefits in the short-term but in a long-term. So, it is not a fee or an expenditure, it's meant to be an investment. In the first two years it was difficult, in the last half hour of the meeting they started talking about it even though they don't really know what to do. They don't ask to look at the model, I should show them the advantages in one quarter of an hour. That's a difficult task because you can't really explain everything in such a short time… This is old stuff now, but management is still looking at digitalisation as a tool...' (Contractor)*

> *'Client board and politicians, government have the money, make the decisions. What is IT? Is it not a tool, it's on the budget. Regarding safety issues we are about 60 people that work full time, how many on IT? Is much less, new machines and so on is popular because it is physical because they do the job. But the administration job is not so important. Where is the competence? It's in the below layers in the middle management' (Contractor)*

Figure 45 shows a summary of the links made in this section.

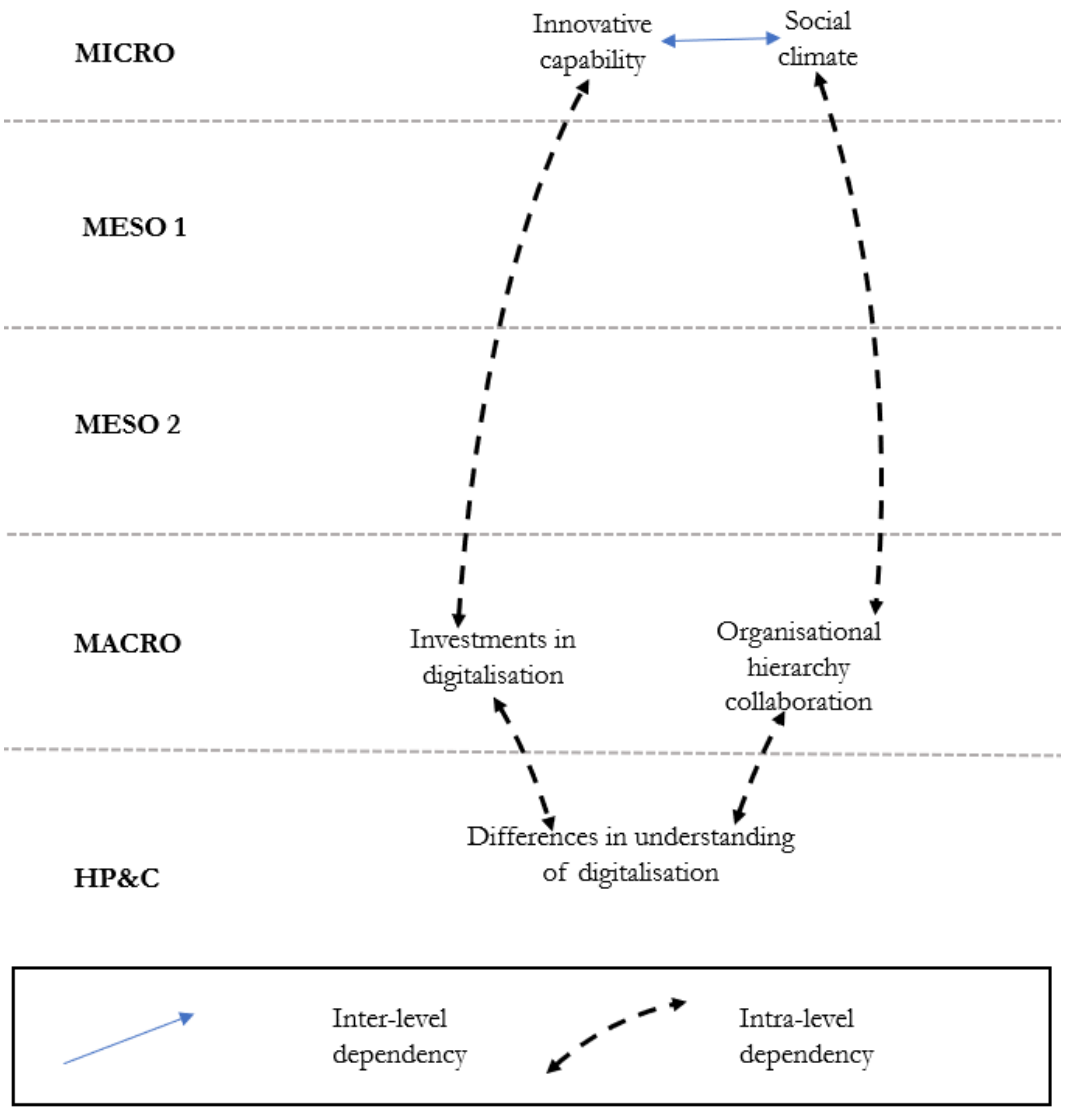


Figure 45: Summary of Section 5.4.2.4

5.4.2.5 Data Exchange and Process Management

The management of the informal (non-tacit) and technical aspects of information delivery are narrated in this section. Figure 46 shows a summary of the links made in this section.

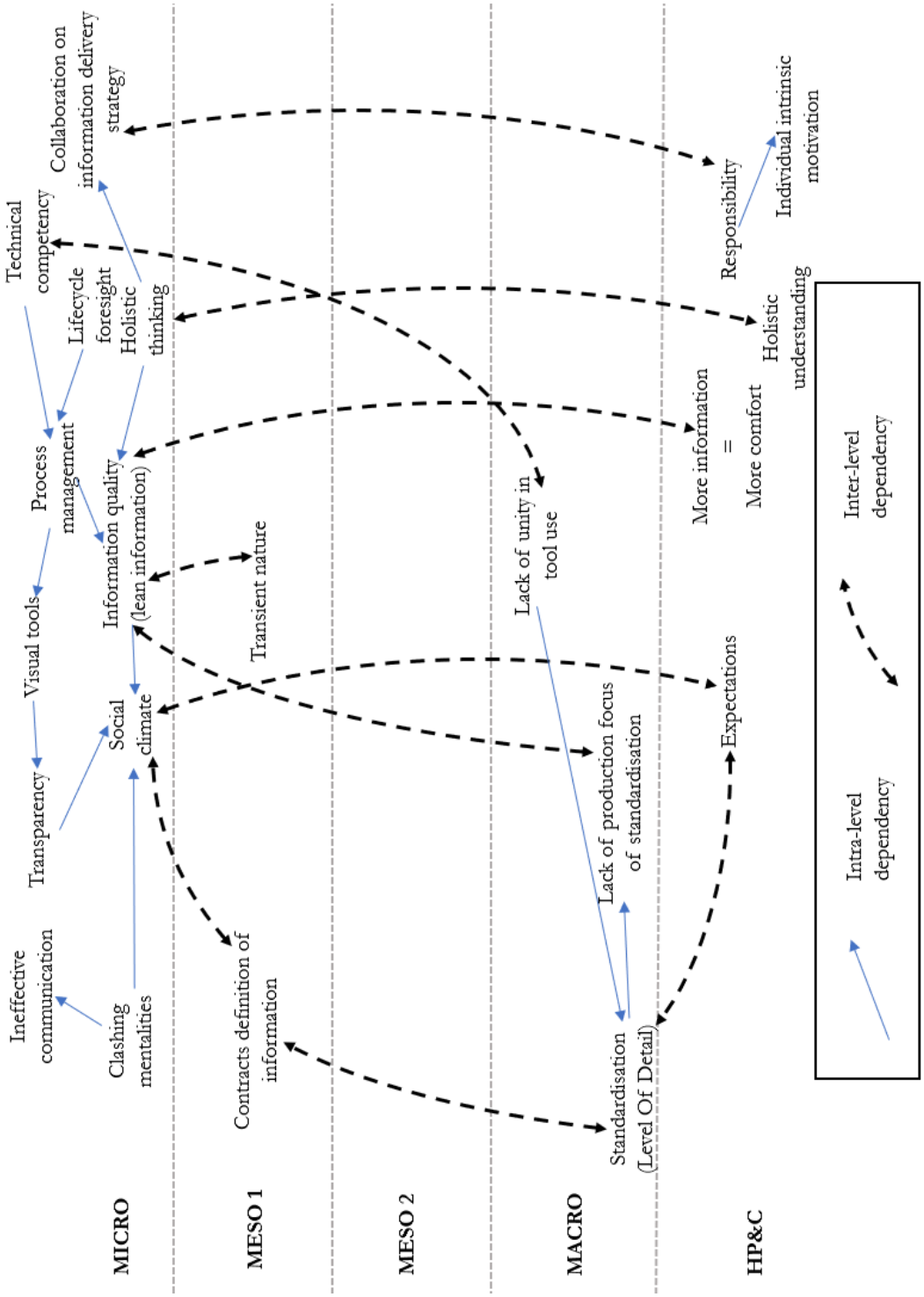


Figure 46: Summary of Section 5.4.2.5

5.4.2.5.1 Communication

The need for optimal communication emerges as a critical factor from discussing the **effect of clashing mentalities** e.g., between a typical contractor and client; the contractor wants the client requirements, but the clients are unable to provide them, that way, the contractor has a way to blame when the social climate and project success is compromised.

Communicating efficiently is negatively related to blame. Blame is partly led by misunderstanding the **informal information** communicated about technical aspects between teams. The effect of BIM is also suggested to improve collaboration by increased clarity by visualisation of overlapping technical aspects. However, the understanding of what is needed at a certain point of communication such as in project level inter-team meetings is raised as a challenge; expectation management is key.

The **lack of dynamic forms of communications** (e.g., face to face interaction) is brought up by a contractor relating this need to the dynamic nature of digital solutions.

> *'Another point I would like to point out is…For example if you ask a contractor in the industry they always answer we need better requirements so they are pushing it on one side, and then the clients sort of sits there and says we need to define everything before we know what we need it's impossible. Then we try to hedge the risk, so then you start to push the blame. It's about setting up the dialogue between the two sides' (Professional Organisation)*

> *'We are not sitting enough together, because we have one meeting every week or two, for two hours and that's it…Digital solutions that should be unified, this is why we need to sit together and do it together. It's more dynamic' (Contractor)*

5.4.2.5.2 Definition of Information

Defining the level of detail of technical information was suggested to be a key factor in developing ways to provide information deliverables as part of contracts. The PO role is to standardise information, the participants explain the challenge without addressing this issue as a cause for differential expectations and causing disruption to the social climate.

The participants from the PM firm who are involved in developing project level processes of sharing information raised that the level of information at a given stage should be linked to the process and the barrier of comfort emerges; people treat the default as what they are comfortable with.

Participants link this to the contractual elements; rewards rather than liability could change the mentality of people to provide better solutions for the whole project rather than their own firm; contributions can be shown based on the level of information.

Besides the need for level of detail, the need to address the **definition of information exchanges in the contracts** is suggested. The definition of information exchange is getting more complex driven by technological change, it seems as though there is a lack of semantics to describe model based exchanges in the contract.

'BIM is making sharing information very easy and tricky to control, so in the olden days with the 2D CAD when you have drawings, you pass it on. With BIM its more than just the 3D models this BIM it's hard to define this in a contract, this information exchange' (Consultant)

'Bringing out the right information, this is what we are trying to do because we try to standardise how we should work and set up the room with the right focus, no fixed table, flexible tables, to fuss up the head, stand up. People do what they are used to doing, always back to comfort' (Project Management)

5.4.2.5.3 Loss of Useable or Quality of Information

The **loss of information quality** was brought up in two focus group discussions where participants explain the consequence of the lack of lifecycle foresight in information delivery. The public client uses the example of a bulb and questions why the information does not flow from the manufacturer to the end-user in the AEC industry; the way information is structured is inconsistent and the information is belonging to multiple parties who work together in a transient manner.

A discussion with a contractor regarding information creation with various software's effect on data structure delegated by IFC. The structure of the data when contractors receive a model is usually inconsistent, which makes a significant amount of information obsolete. The complexity of the data was also suggested to restrict its use. Additionally, the contractor draws **the lack of production focus of standardisation** agencies as evidence of lacking foresight in information delivery. Similarly, a PM participant puts across their concern as to the narrow focus of standardisation organisations.

'We don't get proper IFC, they don't ask for it, so there is no motive to do it. We have 3 to 5 thousand layers of specifications in the cost set up. When stuck in the old tools, it's hard to start. I come from the building industry; the contractors struggle with getting IFC files that work properly because it's so messy. When you can start getting clean good IFC, we have to have a property set up. They are making it so complex, so it has start-up problems… the walls on an incorrect floor and two exact same doors have different names etc. standardisation group who is there, it's not people working in the projects, they are really smart and can IFC, but not addressing the problems from site' (Contractor)

'There is a lot of information lost from start to finish because of the number of people and businesses that the information has to get through to get to operation…. How information is developed is lacking detail, person choosing the bulb brand is different from the person designing it' (Public Client)

5.4.2.5.4 Strategy Definition

Discussions with contractors resulted in the opinion that there is need for their team to be involved **in developing the information delivery strategy** as a symbol of ensuring responsibility and having their identity as part of it, this would intrinsically motivate project level participants. The other contractor also describes the need to get involved and provides reasons for the opinion such as convincing the workforce. The lack of responsibility in strategy definition

motivates the attitude to focus on the negatives. Furthermore, it is evident that the BIM strategy is not given enough value from their workforce when they are not involved in developing it.

In contradiction to the contractor's opinion regarding the ideal situation of giving people responsibility to improve the strategy, the public client develops their own BIM strategy. This strategy is put across in the form of a manual which one contractor calls 'overly technical' and explains the lack of its use. This is consistent with the client's view of poor BIM deliveries as it could partly be as a result of the information requested not being put in the manner that best suits contractors. The public client's BIM strategy is developed like a checklist showing what information is needed for FM and not how it is done, the teams are given freedom to choose.

When discussing about BIM strategies, **the mis-positioned focus of strategy development** was suggested; the focus is on adding detail on the building parts but not how the model is put together in a structured manner that suits all.

> *'The scope in buildingSMART is pretty narrow, it's after all the decision has been made, when you are going to the detailed part after all the real changing parts of the design' (Project Management)*

> *'…even if we get 5 consultants to develop a BIM strategy, it doesn't matter, we need to be a part of it, because it will make us learn about it and we need to develop what suits our organisation in the best way' (Contractor)*

> *'How has BIM really helped? The focus is on getting more properties on smaller and smaller building parts but what about where the parts are going into? From this project, they don't recognise the importance of BIM, they have to see it to believe in it, it is not interesting to talk about it because they don't believe in it' (Contractor)*

5.4.2.5.5 Lean Information

Relating to holistic understanding of needs in the project lifecycle and pertaining to the aforementioned lack of quality of information, by explaining the common mentality, a contractor explains the need to consider all perspectives in developing the strategy of information delivery to eliminate waste.

The PM firm has made lean information one of the organisation's priorities. The participants explain the need for lean mentalities by departing from the common perspective about information. The mentality of more comfort with more information emerges as a typical mentality. By comparing the AEC industry to Oil and Gas (where lean information is a priority), the importance of lean information is because of the exchange across multiple organisational boundaries; leaner information brings less susceptibility to misunderstanding and inefficient exchange.

The tendency to move towards a lean philosophy is not only evident with the PM firm but is used by the public client to disrupt the common mentality of the industry by transferring knowledge from the automobile manufacturing industry.

> *'… it's about what information you really need and what everyone actually needs, it's about streamlining the process. Customising it for everyone, I only see what I need*

and not what he needs. We would have to find out what you need and nothing else' (Contractor)

5.4.2.5.6 Holistic Understanding and Thinking

When questioned on ways that BIM use can be improved, holistic thinking emerges as a result of **the need to add contextual understanding**. A consultant used the need to outsource BIM experts as evidence; BIM needs to be in the skill set of the average engineer, current trends suggests that there is a competency challenge with digital tools. When asked what makes a BIM expert, holistic thinking and understanding emerged. Similarly, a contractor explains that there is need to streamline the process by making people think more holistically to enable people to consider the needs of other teams.

The PM firm explains **lack of holistic thinking** exists in the design firms by stating that the designers tend to design exactly at early stages not understanding that they need to design more light footed in initial stages because of the interactions with other teams' solutions; the interdependent nature of work needs to be understood.

'the actual doers, the guy who designs electricity, he is usually doing it exactly. We don't have the scope but he is making it exact…These guys need to come together and make a strategy for the bid, and establish some kind of dashboard to fulfil the demands in the best way…The problem is that the architect says that I need to know where the shafts are, shaft guy says I need to know the design of the building. I can't tell you how much shaft space is needed because the orientation of the building depends on how much sun, the cooling system is depending on how the decisions are made. You need to iterate more light footed' (Project management)

'For us, there is inherent need to pair the processes and technical tools in the BIM. To provide that in the right context, it's not lack of BIM training, competence, it's putting context so that it makes value because it gets isolated too much and still in too many projects you need to outsource BIM to experts in the business' (Consultant)

5.4.2.5.7 Virtual Design and Construction (VDC)

All the focus group discussions except the one with the public client related VDC to process management and BIM. A common opinion was that BIM would be enhanced using VDC, referring to it as a manner to ensure **transparent and standardised processes**. When questioned further about VDC and its effect on BIM, the PM participants explain that it increases transparency using visual tools, changes the way people behave in meetings because processes are mapped out, better understood and communicated by the leader.

'…depending on the type of task you have to split up the resources, but first you have to understand what the needs of each task are and that's where the collaboration comes. Break up sessions, go out and work and come back' (Project Management)

5.4.2.5.8 Technical Competency

The lack of unity of the use of tools in the industry emerges as alleviating the difficulty to be technically competent as different projects have different teams and therefore different processes and tool use, therefore, requiring standardisation of output.

The public client also raises the **technical competency** challenge in the market relating it to poorly met information delivery; Inadequately structured information was also found to be one of the reasons contractors are unable to further develop the BIM in some projects.

> *'When we talk about BIM, openBIM and open standards…3D models for clash detections, the challenge with that is, it's difficult to learn these tools, you have a tradition of not using digital tools, you have that competency struggle, you get integration between tools, but next time you have to start all over again for this next project, the person who you are collaborating with is using another tool. That is why we need to base this on open international standards, and exchange information regardless of the tool' (Professional Organisation)*

5.4.3 Narratives Centred Around Human and Cultural Themes

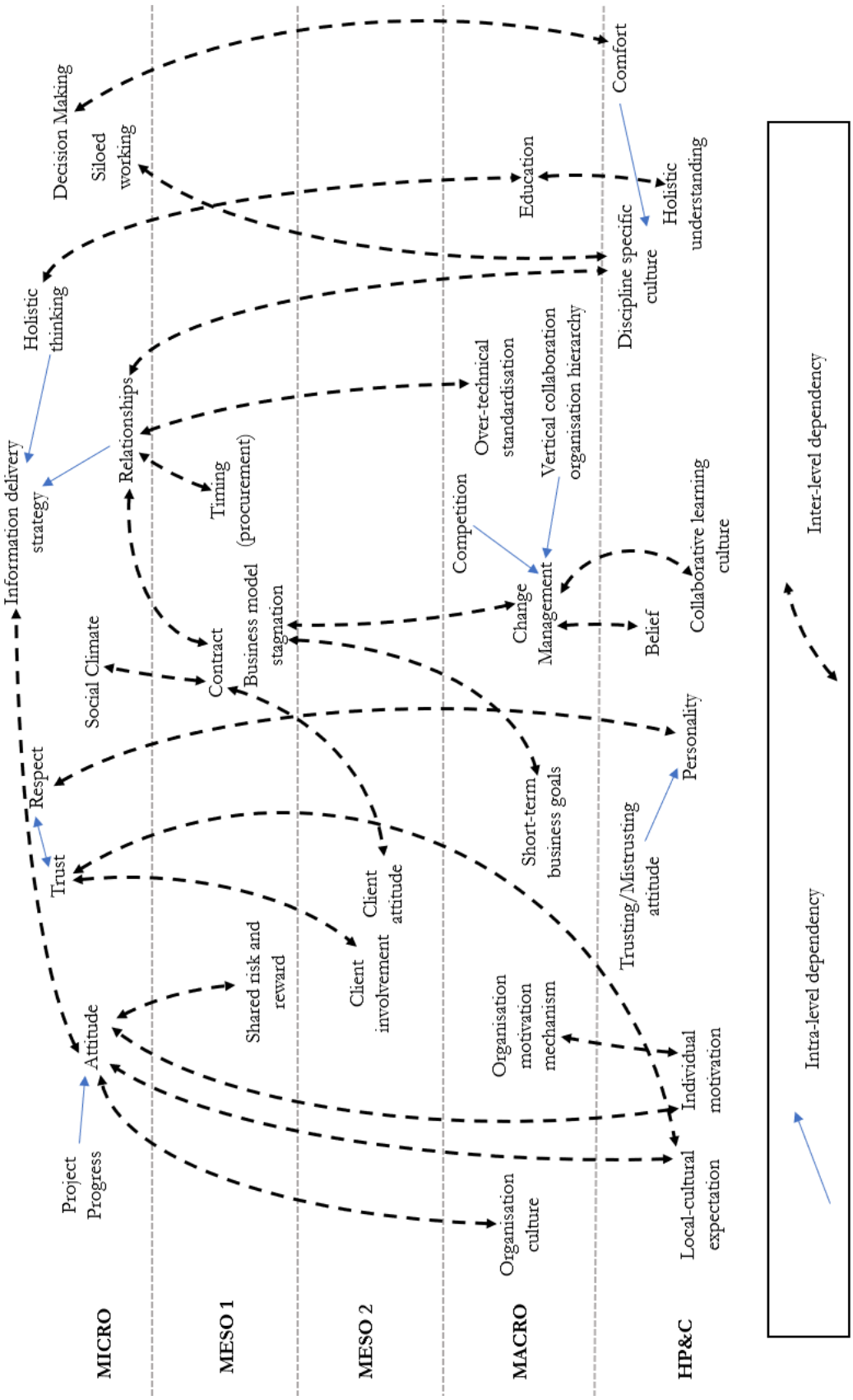


Figure 47: Summary of Section 5.4.3

Figure 47 shows a summary of the links made in this section.

5.4.3.1 Attitudes and Belief

Attitudes of individuals come across as a symptom partly as a result of an organisation's motivation; if the organisation exerts pressure on the individual this makes them focus on profit driving tasks (according to the contract).

One of the participants representing the public client explained **the importance of attitude** in developing an efficient BIMM; it takes patience and learning to get a well-structured BIMM, the right mentality with self-belief, patience and investing time to learn can benefit projects immensely. From the PO, the right attitude means the ability to listen and reflect on one's own way of working, it brings personal development.

Attitudes are also linked to **organisational culture and geographical location** i.e. the PM company is originally in oil and gas and has the mentality from the north of Norway unlike most large firms that belong in the large cities. According to the participants, the PM company higher level management reflect a more open culture as found in the north of Norway.

Both contractors explain that people **need to believe in the changes in delivery**; to make these changes people's beliefs need to be understood and changed by giving them holistic awareness.

> *'The project is complex, and the project and people are affected in so many ways. My thought is that you must bind the important aspects of the project together and to have better IT systems. Awareness and belief are the problem.' (Contractor)*

> *'If you don't have the right attitude then it's a problem, because you keep working based on what you thought and don't listen to others.' (Professional Organisation)*

5.4.3.2 Decision-making

Decision-making is a fundamental process that emerges in every discussion, typically consisting of number of interdependent factors that make people choose the decision in a context.

When considering change management, **comfort in the way people handle changing processes** emerges. The discussion with the project management firm had realised that people tend to fall back into what they are used to doing (comfort). For example, the use of a round table for meetings is normal but the PM firm changed to flexible tables where people have to stand up and interact with visual and tangible tools. This way, improvements in the level of interaction between team members was claimed.

A contractor explains the **impact of competition** on the decisions to adopt changes in the way they operate; if the competition is pursuing a type of innovation, the higher level management are more likely to agree to the investment.

The ability to think holistically was shown to be the difference between BIM experts and other professionals. When questioned, a participant explained that the BIM expert understood everything other than the technical aspects as well as they understood the technical aspects. When asked to explain, participants explain that it is to do with the contextual

understanding of BIM and how it adds value to the entire project which made it clear that there was missing holistic understanding. Experience tends to increase the ability to think about the soft side as there is more exposure to aspects of the business and lifecycle; from experience people tend to deductively reason contextual factors as a result to exposure to other perspectives.

One of the participants was a recent graduate who taken a course involving modules that included BIM. The participant denies receiving the understanding of the 'soft side' in education and explained that the education was predominantly tool based and numerical. One of the more senior members of the group explained that the soft side is not commonly taught but comes from experience.

> *'Competition affects us because management will listen to us if the competitors are doing it, if they feel that we are behind then they will listen. Survival of the fittest' (Contractor)*

> *'it's the soft side of things… its putting context so that it makes value because BIM gets isolated too much and still in too many projects you need to outsource BIM to experts' (Consultant)*

5.4.3.3 Holistic Understanding and Thinking

Holistic understanding is brought up in all discussions in relation to a number of aspects. With regards to the technical aspects regarding information delivery, it is suggested that there is an **over-emphasis on the properties of objects** rather than the manner in which the parts are combined; a model's building objects rather than process of bringing these objects together in a meaningful manner.

A participant exemplifies the lacking holistic understanding as standardisation organisations tend to treat the construction project like a standardised product rather than a creative combination of products.

Similarly, **the underestimation of the complexity** of construction projects is common where the primary focus is the tangible technology whereas this only represents a small part of the overall process of delivery. Other significant parts include e.g., organisational and competence challenges.

Similarly, a public client representative explains that there is need for awareness of the other hidden factors, the fundamental understanding of project delivery needs to be reinforced, so that this understanding can be taken to all projects.

The holistic view in **managing information** emerges in numerous occasions. For example, a client explains the need to rethink the use of BIM and relates this to the business model's restriction of **information transfer through the lifecycle**; the business model is within the project lifecycle whereas value can be added in the building lifecycle from project level practitioners including more efficient information delivery for later parts of the building lifecycle.

With regards to **transfer of information through the project lifecycle**, the project management participants reiterate the need to utilise D&B contracts to enable the transfer of production information to design considerations. The consultancy group also explains that the

company have discovered higher profitability when involved in a larger part of the lifecycle as they can benefit from streamlining the process. When a firm's operation is restricted to a shorter part of the supply chain, it can be perceived that even if the firm's representatives have holistic understanding, their ability to streamline processes for later stages is limited by the way they do business with other firms.

When consultants were challenged to question why the **contracts and business models** are not changed, the discussion went quiet with uncertainty, the most senior member said that it was because of short-term business goals.

The end-product of information use in FM is raised, suggesting that firms need to be incentivised to think far ahead of the construction phase by getting involved in managing buildings. This statement further reiterates the need to encourage the use of holistic understanding (holistic thinking) by making suitable changes to the business model.

A contractor explains the lack of a holistic view in **the higher-level management** who view digitalisation as non-systemic with the focus on tools. As previously mentioned in the context of decision-making, evidence suggests that **education seems to over-emphasize technical aspects** of information sharing rather than the 'soft side'.

> *'Academic development is too far ahead. We have to focus on the low-level success' (Contractor)*

> *'we are treating it as a standardised product. I think that we should think of the construction project as a new development… It obviously depends on a large number of complex factors' (Professional Organisation)*

> *'We always misunderstand the complexity of construction projects, we put too much on the technical side. We don't put enough effort on the soft side… but it's more about awareness and the need for collaboration or correct share of information. Biggest challenge, is always doing it in all the projects, arguments are different.' (Public Client)*

5.4.3.4 Local Industry Culture

The discussion with a contractor indirectly shows the importance of considering **the local culture of the industry**. The participant used an example of a Norwegian project manager who tried to implement systemic innovation in another market and failed to replicate, calling for the need to understand the local context when making changes. Another example put across by another member of the group was regarding local work ethics where an American project manager demanded an employee in Norway to work overtime which didn't work. The Norwegian work ethic is socialistic and expects people to be honest and come to a conclusion together on who would be most suitable to take up the extra shift.

According to the PO it is normal to have a blame culture in the AEC industry, when probing for reasons a number of factors such as a perfectionist culture and lack of accepting failure arose. The culture emerging from designers shows that there is a **culture of working in silos** with a lack of holistic understanding which is described as a barrier to systemic innovation.

Additionally, in the context of the Norwegian industry, a reliance on drawings emerges in discussions with a contractor where the reinforcement bar manufacturers are used as an example; the expectation is orders presented with a traditional bending schedule. (Section 5.4.2.3)

The discussion with the PO brought about the **lack of collaborative learning culture** using an example of a hackathon; the practitioners are not used to learning together showing challenges in acquiring competency collaboratively.

The public client is involved in driving the digital revolution of the industry and is supported by the government in doing so. The ideology behind the driving force is to provoke the market by doing something different. The idea is to provide the industry with an example best practice to increase awareness because of the strong cultural constraints of the industry which are holding back true systemic change.

> *'Local culture is also a problem because for example there was a project manager who went from Norway to Germany, but he was struggling to make decisions because of the local culture, and it came to the point where he was forced to change or he would not survive. He invested into development of digitalisation. Drivers for change are a bad experience. I do see a paradox, have they really got the context to make changes?' (Contractor)*

> *'I agree with your focus, we have the technology, but the people is the hard way, moving from the traditional thinking from I describe my need and you do it and if something changes we meet again and get a new price and argue and fight about that or we go to court' (Professional Organisation)*

> *'Engineers don't like soft things. We also have a reward system for this with our client. Engineers don't like anything like statistics, we want something certain. Soft values with hard targets' (Project Management)*

5.4.3.5 Motivation

A project management participant explains, 'the biggest problem is to collaborate if something goes wrong' suggesting that the motivation of teams reduces when project success is questioned and impacts the social climate. As explained in Section 5.4.2.2.2, the example provided by the participant in the PO shows motivation has a relationship with the manner in which client's manage the contracts and financial aspect via their relationship with the teams. Additionally, as discussed, it could be that the client's attitude is inherently related to the business model and contracts itself; when the business model and contracts were altered coupled with new leadership with a more open approach to management, the social climate improved and provided better value for the client.

5.4.3.6 Openness

The need to work openly emerges in all focus groups except with the public client who tended to talk mainly about the macro level aspects. The project management firm have made it part of their company's core using lean; by being open with various teams, the silos can be broken.

The **benefits of openness** are suggested to be leading to positive project outcome, a contractor explained that being open can 'win months'.

The consultant relates shared risk and reward to more openness and values such changes in contracts suggesting that it would bring **changed mentalities** to suit open team environments.

> *'Changing the rewards and penalties... changing the mentalities. I think that more openness is important' (Consultant)*

> *'We need to work as a team inside, not in silos but to work openly, together with suppliers. We have the lean foundation…now we train suppliers' (Project Management)*

> *'if you can be open and face the problems at an early stage then you can help each other and it's a nice way of working and always get good results. If you see any projects not going well, I have no statistics, but you can see that being open can win months. Also, that situation of helping each other cannot have a bad project' (Contractor)*

5.4.3.7 Relationships

One of the challenges in having strong relationships is **the business model's transient nature**, where teams need to consistently work with new teams (timing). The discontinuity means that project management need to start from zero to get teams to trust one another. The public client explains the two procurement routes utilised for their projects; fixed price D&B or DBB. It is suggested that the relationships with the client are different where DBB ensures closer collaboration with the designers. However, vice versa with D&B. It is clear that the business model impacts the social climate of a project by restricting the way people build relationships.

Differences in mentality between designers and contractors was suggested to constrain relationships between them. The mentality is as a result of education, nature of work, organisational culture (Section 5.4.2.4). Additionally, showing a difference in relationship with the client in typical infrastructure projects. Contractors claimed that the clients are more accessible to the consultant in typical projects.

Furthermore, the need for strong relationships and collaboration is related directly to the business model and the information development process as different businesses own different parts of the BIMM. To facilitate changes in the way relationships are made and developed, the way that the firms get paid needs to change according to the public client. A participant from the consultant group explains the ideal **motivation of good relationships** is having mutual gains.

A contractor and PO explained **the importance of developing relationships** with start-up informal activities. However, the majority of engineers feel that this is a waste of time, reiterating that there is a lack of perceived value in the hidden non-technical factors.

> *'The part of the BIM process from the beginning to the end is also because, different parts are belonging to different businesses, that's why it's important for businesses*

to collaborate efficiently. This is why the business models need to change, to facilitate people to work together, the way they get paid needs to change' (Public Client)

'The difference in the contrast in the thinking of digitalisation between contractor and consultant is large, the consultant are making it work by themselves, the client is more accessible to them... but for us it seems that the client is further away…' (Contractors)

'Mutual gains, it boils down to, we discuss it openly…definitely completely trusting relationship' (Consultant)

5.4.3.8 Trust

Trust emerged in all focus group discussions except the discussion with the public client who had low focus on the project level concepts and focussed on the industrial level. A participant from the PO signifies **the importance of trust** and perceives the lack of trust as a cultural phenomenon that emerges in the form of blame, calling it foundational to project success. A contractor relates **trust, respect and the ability to listen** to collaboration; a complex combination of individual characteristics, culture and environment.

Trust also emerges from **the local culture**, with respect to the example in Section 5.4.3.4, there is a link with the socio-cultural expectations. The ability to trust one another's intention can be linked to how people trust from a cultural perspective, people are not expected to be dishonest in Norway; this becomes evident when a group describe past experiences working with foreign firms.

Trust is also suggested to be vital between client and the contractor; a contractor claims a lack of trust with public clients in Norway.

'Trust is a big issue. Also, the client trust. It's foundational. If you are trying to govern an IT project in this way you will see the same kind of result because you have a complex task, you obviously don't know everything beforehand. So, you need a process to manage the ways and if you start by putting blame at the beginning of an it project, then, it's going to die' (Professional Organisation)

'…if you don't have trust, it gets difficult, if you are mistrusting, you are not interested in collaborating with another person. It is connected. If you feel that you are not being respected, then you will not be able to trust the other person. I will not respect or trust the other person if I see that he is not listening to me' (Contractor)

5.4.3.9 Personality

Using deductive reasoning a participant from the PM group explains the **importance of personality**; the individual representing a firm makes the difference to the project suggesting personal characteristics are important.

From the discussion with the PO, the ability to respect others is important as part of a collaborator's personality. The participant added that there is need for the team members from different teams to listen to one another which depends on his/her personality. Furthermore, the tendency to trust is also a personal characteristic; if a person has a 'mistrusting attitude' then it is difficult to collaborate.

'I think it is part of the same, if you don't have trust, it gets difficult, if you are mistrusting, you are not interested in collaborating with another person. It is connected. If you feel that you are not being respected, then you will not be able to trust the other person. I will not respect or trust the other person if I see that he is not listening to me…I have been working in this industry for 20 years now, I have experience in working with people who are difficult to collaborate with. That feeling that you are stuck and not collaborating well is coming from no respect for each other and therefore not listening to each other' (Professional Organisation)

'We tend to think that companies operates always the same, so it depends on the team. We know that these 5 companies work well in these projects, people may be booked in another project so then we have new people, so it makes a difference' (Contractor)

5.5 Summary

The results from the primary data collection were presented in this chapter. These results are compared to literature and the HMC-AEC is developed in Chapter 6 that is suitable to generalise the factor interactions found in this chapter.

6. MODEL EMERGENCE

6.1 Introduction

This chapter puts the narratives discussed and summarised in Chapter 5 in context of a suggested model categorised with an existing external analysis model (see Figure 48). Human Psychology and Culture is added to suit the nature of empirical evidence presented in Chapter 5, this is discussed in Section 6.2.5.

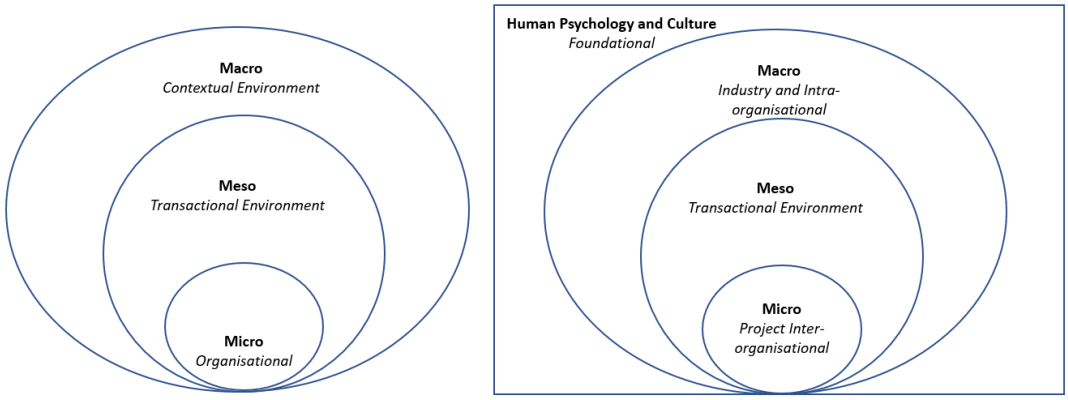


Figure 48: Left - Original External Analysis Model Structure, Right - Updated External Analysis Model Structure with Human Psychology and Culture, (Adapted from Van Notten *et al.*, 2003)

A summarised interpretation of results stating the perceived interactions within the suggested Holistic Model for Collaboration in the AEC industry (HMC-AEC) is discussed. The links between these interactions and existing knowledge is also presented. The objective of this chapter is:

- To develop a multi-level model that suits interactions between Human Psychology and Culture, industrial and organisational, client, contractual and procurement and project level collaboration factors (SRQ4)
- To understand the interactions of factors that affect collaboration at the project level from empirical evidence and literature to develop a general model from interactions (SRQ3 and SRQ4)
- To focus theoretical application and discussion on a level that is both practical and impactful (SRQ5)

Section 6.2 describes the links between these levels using the data collected and existing knowledge. Section 6.3 provides a summary of the meso level on the basis of the conclusions made from the model presented in Figure 49 and the matrix in Table 18 shows assumptions used to select the meso level as the most practical factors to focus industrial changes.

6.2 Micro, Meso, Macro and Human Psychology and Culture Level Interdependency of Collaborative Environments

6.2.1 Overview of the Holistic Model of Collaboration in the AEC industry (HMC-AEC)

Figure 49 and Figure 50 were developed to represent the nature of the data collected; by studying empirical data collected from project level participants (micro perspective), a better understanding of the contextual factors (macro), both of which give insight to the transactional meso level. Figure 50 shows an overview of the factors categorised under micro, meso, macro and Human Psychology and Culture (phrases in italics refer to symptomatic observed problems). The micro level of the inter-organisational network is respective to the factors that affect the manner in which individuals interact at the project level whereas the macro level is considered with the independent organisational level (Staw, 1984); e.g., the underlying aspects that defines the manner in which an organisation operates. The meso level on the other hand, is associated with the transaction of the macro (independent organisations) to the micro (inter-organisations) level as they cannot be treated separately (Rousseau and House, 1994). Organisational literature refers to the micro as organisation, meso as transactional and macro as contextual as shown in Figure 48 (Van Notten et al., 2003), the same logic is used here and applied to AEC project delivery. The proposed model is categorised in the levels of analysis used in macro-sociological and organisational behaviour literature which optimally suited the nature of the factors.

The key difference between the model proposed and that used commonly by Van Notten *et al.*, (2003) is in the findings of factors that are affecting all micro, meso and macro level aspects. In this analysis, these factors are referred to as Human Psychology and Culture (HP&C) as they represent psychological and social fundamentals that affect human behaviour. Elements such as psychological comfort, tendency to trust, etc., (shown in Figure 50) affect all human interaction suggesting the need for an additional level under the original categorisation (further discussed in Section 6.2.5).

In Chapter 5, this categorisation was used to summarise interpretations between themes in each section of the results. In this section, these interactions between themes are generalised (when possible) with support from literature and therefore presents a holistic perspective. The aim here is to provide better understanding in the way multilevel phenomena interact. Therefore, giving the research a novel perspective by combining knowledge from multiple levels as represented by empirical reality owed to the holistic nature of data collected.

The link between micro and macro via meso is evident in the data as participants explain that the way a project is managed depends on external factors (macro) and affects individual behaviour (micro) in a project. Further increasing the complexity is that the HP&C level also has a direct impact on the micro level. Evidence suggests that even though personal traits from HP&C with respect to an individual can be perceived as positive for collaborative behaviour, if the meso

level is not incentivising collaborative exchange people will be uncomfortable in collaborating. In other words, the meso level contributes towards the how HP&C factors are applied in the context of a particular project. Keeping in mind an individual's natural tendency, people start behaving according to the environment they are presented with; a combination of nature and nurture contributes to behaviour in practice. In this section, each dominant factor is discussed in relation to literature and the data collected to show the evidence behind the positioning of the factor and their multilevel interactions.

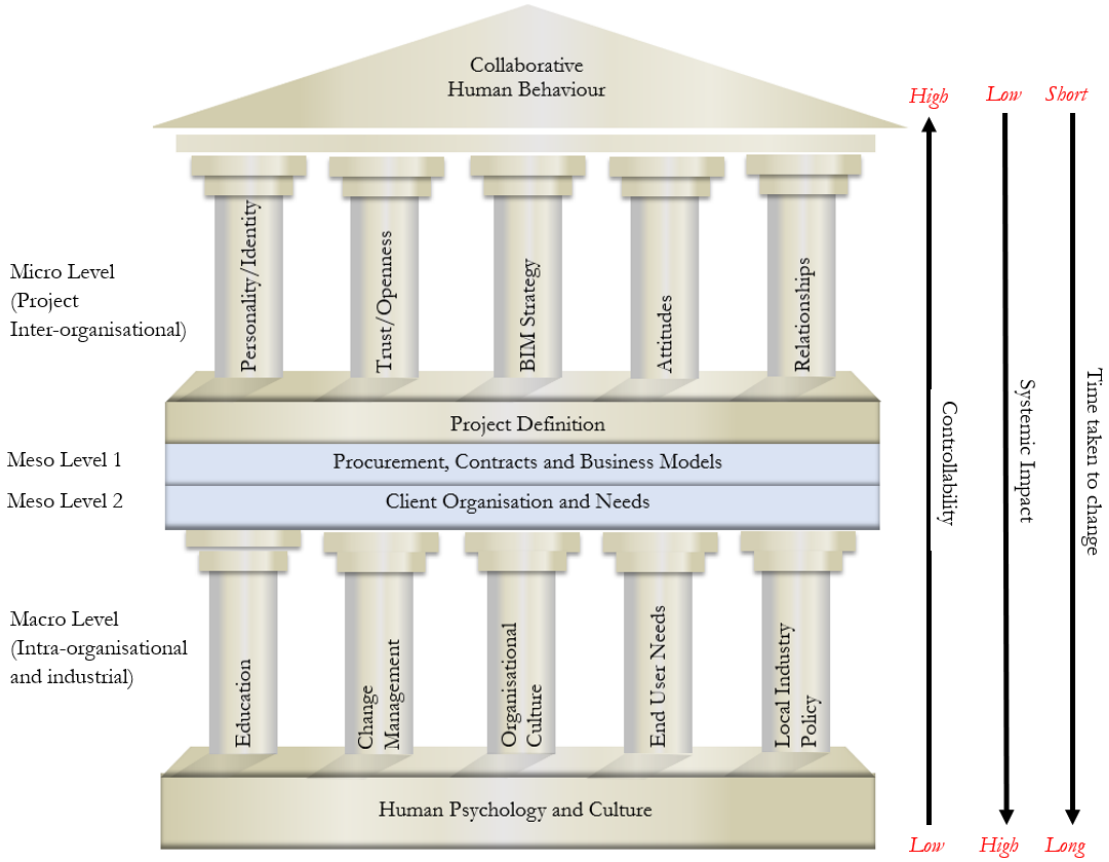


Figure 49: Overview of Holistic Model for Collaboration in the AEC industry (HMC-AEC)

With reference to Figure 49, three variables were used to decide the focus of the theoretical application and to centralise discussion. Controllability is defined as the ability to influence factors with project strategic intervention. Controllability was implicitly obtained by the way that the participants who work in the project level provide explanations of how the factors affect collaboration. The time taken to change represents how long it can take to make these changes to a factor. Systemic impact is defined as a measure of the effect on the other levels of the model. The time taken to change is shown as increasing towards the foundation of the figure. The opposite applies to controllability and systemic impact. This is also represented in the form of a matrix with scale 1 to 4 in Table 18.

Table 18: (Left) Impact-Controllability-Time Matrix (Right) Scale Definition

Level in Model	Impact	Controllability	Time Taken
Micro	1	4	1
Meso	2	3	2
Macro	3	2	3
Human Nature	4	1	4

Scaling Factor	Meaning
1	Low
2	Medium
3	High
4	Very High

From these two figures it is proposed that the meso level is the most controllable considering time taken and with considerable potential for systemic impact. Section 6.3 shows the summary of issues taken from empirical evidence perceived as the current challenges in practice. These issues are referred to in Chapter 8 as the foundation to application of decision-making theory to further understand the origin and effect of these issues.

The following sections describe empirical data and literature starting from the top to the bottom of the model shown in Figure 49. The model of the generalised factors (Figure 50) placed within the structure described in this section should be perceived according to the definitions of this structure. The structure represents an interdependency which is made more transparent in following sub-sections and Figures 51 and 52; the interactions described and shown are within the context of Finland and Norway. The model is different from other models because it places the factors in a hierarchical structure whereas other models just explain the existence of the factors; the value added is from going to a higher level of generalisation.

Figure 50: First Version of Holistic Model for Collaboration in the AEC industry (HMC-AEC)

6.2.2 Micro Level Factors

This section explains the emergence of micro level factors and triangulates them with existing knowledge. It is important to note that these factors are affected from other levels of the HMC-AEC which are also highlighted in each sub-section. The micro level can be perceived as the easily observable symptoms of the underlying causes of meso, macro and HP&C levels; connections to other levels are made throughout this section.

6.2.2.1 Trust and Openness

Trust is fundamentally important in collaborative environments such as in AEC projects (Lechler, 1998; Gad and Shane, 2014) that depend on human interaction; reiterated by its direct mention in all Study 1 interviews and 2 of 5 focus groups in Study 2. Trust is one of the symptoms resulting from complex interactions of other factors some of which are from other parts of the model. The high emergence in Study 1 could be attributed to the research design; interviews with participants from the Project Management (PM) firm gave a better idea of the micro level interactions as most of the interviewees are involved in management activities operating at the centre of the project team, e.g., facilitating face to face interactions. However, in Study 2, although trust does not emerge as much, other micro level traits emerge; this may be due to the greater mix of perspectives driven by the research's design being with multiple firms operating in different parts of the supply chain. The position of trust emerges at the micro and HP&C levels. Factors that affect trust emerged from interactions in the macro, meso and HP&C levels; perceived as enablers/inhibitors of trust and openness.

Trust between project level participants is inherently linked to information sharing and therefore information latency (Wood et al., 2002). Data collected supports the idea that a more trusting project team would be less susceptible to cognitive latency (see Section 2.3.4) as a result of increased openness.

Study 1 shows that trust is strongly linked to the financial incentives of the project and therefore linked to the way that the contracts work (micro-meso). A number of studies have related various procurement routes to the way teams trust one another (Kumaraswamy et al., 2005; Laan et al., 2011; Guo et al., 2013; Gad and Shane, 2014; Che Ibrahim et al., 2015). Findings support that it is important to consider procurement routes, however it is more complicated than just having a contract or business model that incentivises trust (Strahorn et al., 2017). Although contracts and business models are at the centre of the proposed model, it is important to focus on the other aspects that are suggested in the model to consider the impact on trust in developing a positive interorganisational collaboration environment.

Trust is said to facilitate alignment of partner interests (Atkinson et al., 2006). The importance of trust is also evident as some participants indicated that the formal contracts would not be referred to if a group of teams who trust each other work together, rather when problems emerge, collective working enables better dispute resolution. Therefore, a link between micro

level trust and the way the contracts are perceived. This means that empirical claims of some contracts inhibiting trust appear realistic, although it is also dependent on the social climate. Developing openness between teams was found to be dependent on respect which was related to trust between teams.

Trust on the basis of individual interaction emerges in multiple contexts in the data. In process management, when physical meetings are more interactive it was suggested to build trust (HP&C – micro). More interaction means people can get to know each other facilitating a higher probability for building trust between them.

The stress on daily management from a leadership point of view was found to reduce with more trust between project participants (micro). The value of trust between teams was suggested to be perceived as lacking significance, people tend to focus on themselves (individualism; HP&C) resulting in the lack of effort in developing trust. Where contracts and strategy are concerned, trust and collaboration are put across as a requirement in contracts indicating high importance. However, from empirical data the contractual needs were not being translated to the project level (meso – micro). This is also symptomatic in the siloed nature of normative working practices (HP&C); meaning that typically people think working in silos is normal and therefore, it is typically assumed as the best way of working.

6.2.2.2 Project Level Attitudes

The attitudes that individuals bring to the project level environment are suggested to be related to all levels of the model. From HP&C, working with people with open personalities was found to be a prevailing perspective suggesting that open people tend to have better attitudes at the project level as they put across their perspective in a more flexible manner (HP&C – micro).

Evidence of the nurturing effect of the macro and meso level; some participants explain that 'good people in a bad environment can become bad' or vice versa. Furthermore, the personality of an individual restricts or alleviates mentality according to the environment (micro - HP&C); natural characteristic interacting with nurture from the project environment. For example, in a strong liability and blame-based environment, people are forced to defend their firm and therefore alleviates their attitudes at the project level, therefore, have to react differently from their natural state because they are presented with a different environment. From psychological literature, it can be justified that the personality does not change so quickly (Allemand and Flückiger, 2017). Empirical data suggests that the negative traits of personality can become more apparent to the collaborators when there is a negative environment and vice versa with a positive environment.

The link between motivation and attitudes is apparent in relation to the contracts. Meso level was also connected to micro level attitudes by the effect of liability-based contracts incentivising defence of their team resulting in blame-based behaviour at the project level. Reiterated by literature, firms working like polarised service providers are suggested to generate

major obstacles in enforcing common values, goals and orientation in projects (Bresnen and Marshall, 2000a; Dulaimi et al., 2002). On the other hand, the positive effect of Alliance contracts where risks and rewards are shared was suggested to increase the use of holistic thinking and therefore uniting the teams in better collaboration.

The attitudes stemming from differences in culture between individuals at the project level and groups at the national level require a micro level based study taking into account the macro level (Phua, 2013); the author questions whether there are individualistic traits from the local culture of the industry also contributing to the adversarial attributes of the micro level. The empirical data supports this hypothesis as the cultural expectations from the local culture impact human behaviour in a project. This is evident from the difficulties created when foreign firms are procured for the first time in a new environment to them. Openness about changes or problems at the micro level was related to the team's experience of the industry culture (macro - HP&C); for example, from Study 1, Estonian contractors who are not accustomed to the Finnish industrial culture are claimed to be not open enough about problems when first operating in the industry. However, as they gain experience operating in the industry, the openness is nurtured closer to the local cultural norms.

6.2.2.3 Information Delivery Strategy, Lean Information and Process Management

The information delivery strategy was found to affect multiple factors from all the other parts of the model. From literature, BIM adoption has been much slower than anticipated (Ghaffarianhoseini et al., 2017).

The practicality of strategies emerges; contractors explain the lack of use of information delivery strategies put forward by some clients resonating with their employees' perceived lack of value (they do not see the added value to their firm). Literature also expresses the need to develop practical strategies for information exchange and integration in BIM (Matarneh and Hamed, 2017). Evidence suggests that there needs to be personal involvement in the development of strategy to ensure project participants invest by feeling responsible for information delivery.

When technical competency was raised by a public client representative, it resonated with the contractor's view. There seems to be a lack of competence in the form of knowledge and experience to understand the needs of the client in defining the information requirements. This lack of competence can be perceived as a divide between the client and rest of the teams, which is also apparent from the lack of micro level related data from the public client in Norway.

The challenges of achieving technical competency can be related to the paradox of choice (Fernandez, 2017) in connection to the way software is used and procured in the industry. The transient nature of construction means that people are required to use different software packages depending on the project's strategy and due to the lack of collaboration between software vendors. From the academic point of view, improved definition of transactional process models to eliminate data interoperability issues is needed (Matarneh and Hamed, 2017). This lack of unity

makes the need for open international standards important although this can be challenging because of the cultural and lingual differences. Furthermore, this enables one to question whether the need for versatility of skills is causing difficulties in competency – are people used to continuous learning or are they used to repeating processes? Azhar (2011) explains the need to lessen the learning curve for people, however, it is arguable that without significant systemic non-micro level changes this may be challenging to achieve; is the role of people in industry a symbol of the need to fundamentally change the way industry operates and creates value?

Transparent and standardised processes in management were suggested to be supported by the use of VDC, which can be simply understood by making the PM perspective of the project more visual and apparent to project participants (uniting vision). The claimed need for lean information was related to the Building Information Management Modelling (BIMM) typically having excessive information in an inconsistent structure, this was related to psychological comfort (HP&C – micro) with more information (Section 6.2.5.1).

Information loss is not newly documented (Teicholz, 2013). However, the reasons for information loss are not well understood in the literature. The empirical data collected shows that the quality of the information is not optimal for Facilities Management (FM). The nature of the technical information that (e.g., in BIMM) is a result of multiple teams developing information in different software packages united using IFC. However, this lack of unity in software use results in data structured differently from complex data integrations evident from when contractors want to develop the existing BIMM. The lack of production focus of standardisation; a symptom of this is in the IFC passed on from designers to contractors who claim that 'messy' models make the BIMM difficult to use and understand. Additionally, a Norwegian standardisation agency had only 6% of members as contractors (BuildingSMART, 2019). This allows us to raise the question whether the standardisation organisations may be biased towards the design part of the lifecycle?

The mis-positioned focus of strategy development was also evident in the manner in which standardisation organisations are working. The value added to the project was found to be in the detail of the building parts but not in the way the parts come together suggesting lack of influence on the process of design. This brings a knock-on effect to other players (e.g., the contractor) later in the lifecycle (macro-micro).

A Norwegian consultant explains that a BIM expert is different from traditional employees as they were said to have greater contextual understanding. Holistic understanding of the process is a critical part of the contextual understanding. Symptoms of lacking holistic understanding include over-precise design solutions at early stages and the low use of maintenance information in the design stage. However, this may not be because of the lack of the capability to think holistically or contextually but may be the lack of motivation to apply the knowledge as this is not incentivised or perceived as normal practice.

Defining the level of detail of technical information to avoid over-precise design and unite the management of the process was reiterated. The increased complexity of information delivery from the use of BIM was related to the difficulty in the definition of information exchange in contracts. A large amount of literature exists on the contractual barriers to information delivery (Azhar, 2011). However, literature fails to question or connect the motivational aspects of contracts to these barriers. From the empirical evidence it can be argued that there is a misalignment of innovation and business models (further discussed in Section 6.2.3.1.1) where a symptom of this need is in the challenges of implementing digitalisation. This signifies underlying barriers in lower levels of the HMC-AEC.

Informal information in this context is the non-technical tacit forms of information e.g., thought processes or experiences. Evidence suggests a lack of transfer as there is no strategy to make the non-tangible information into a reusable tangible form; some participants claim that people are more valuable than they should be as the information is not recorded and moves with people. Literature supports this need, to integrate and manage tacit knowledge to enhance performance of AEC firms (Pathirage et al., 2007). From a human resources perspective, the replacement of people during a project results in changes in the collaborative environment. The low perceived value of informal information (also referred to as 'soft' information) is suggested and connected to the siloed nature of education (macro – micro). The lack of tangibility of informal information was found as a possible reason for lack of dynamic forms of communication. Lack of face to face interaction was used by a contractor to exemplify this need, also to unify increasingly complex and systemic digital solution.

Familiarity with the leader's process of coordinating information is important because the iterative nature of design requires locking the design to levels of details and there are a number of ways to do so; a paradox of choice (Fernandez, 2017). This requires familiarity between teams (see Section 6.2.3.1.2) going against the nature of practice delegated by the transient and fragmented business model.

The contractor's need for better requirements coupled with the client's lack of knowledge of their needs was related to more susceptibility to a blame-based attitude resulting in clashing mentalities (meso – micro).

6.2.2.4 Motivation at the Project Level

Inconsistent leadership as a result of contractual strategy was related to loss of project level motivation (micro – meso). In the traditional business model where the client uses separate leaders for design and construction, later changes in the design when the contractors come onboard result in rework in design and therefore loss in motivation (meso – micro); another leader means a change in vision and expectations. Early contractor involvement has been related to improved design outputs resulting in optimized schedule time (Song et al., 2009).

Typically, when a dispute arises, the impact of the liability-based contract results in blame-based attitudes. This brings team demotivation as they have contract driven reasons to professionally use to their own benefit (opportunism). The data suggested that some motivation aspects arise from contracts and business models as explained in Section 6.2.3.1.1 (meso – micro).

6.2.2.5 Relationships Between Teams

Collaboration and relationships between teams at the project level emerges as increasingly important as different parts of information delivery are owned by different firms operating at various parts of the lifecycle (micro – meso).

The benefits of positive relationships; increased team spirit in production teams, although, challenges originating in the transient nature of procurement were expressed requiring consistently making new relationships at different parts of the project lifecycle (micro – meso).

Barriers to relationships from natural characteristics that are associated with team chemistry were found to most likely break in social activities. By increased understanding between one another in a social activity, team cohesion develops (Maurer, 2010). However, positive relationships and trust was found to be not always possible suggesting that the natural characteristics of people (e.g., their personality) representing teams sometimes do not allow it (HP&C – micro). Positive trusting relationships were suggested to emerge from mutual gains (meso – micro).

In building relationships, it is important to develop an understanding of the expected and required attitudes; the need to understand the formalities that play a part in the tone of communication and to understand other individual's work habits.

6.2.3 Meso Level

The meso level can be perceived as the way that macro level factors are translated into micro level factors all of which depend on the HP&C characteristics. Two levels are described below including the contracts, procurement and business model (level 1) and the client (level 2). The client is a key stakeholder in the building lifecycle. In typical projects, they are involved in all significant project level decisions including developing meso level 1 strategies, which therefore make contract and procurement selection dependent on the client. This section is split into two parts; Section 6.2.3.1 discusses level 1 and Section 6.2.3.2 discusses level 2.

6.2.3.1 Meso Level 1: Procurement, Business Model and Contracts

6.2.3.1.1 Contracts and Business Model

The effect of shared risk and rewards results in an increased willingness to share information as compared to traditional liability driven contracts (meso – micro). Sharing information can be perceived as a risky process for a team as this can bring critique from other teams. In liability-based contracts this can be perceived as giving the other teams a reason to blame by finding mistakes. From both empirical evidence and literature, in the case of contracts with shared risks

and rewards, the risk of liability is significantly reduced and therefore facilitates the openness in sharing information (Glick and Guggemos, 2009). Trust, openness and attitudes between teams were also suggested to be impacted positively. Additionally, improvements in client satisfaction signify the effect of positive collaboration driven by changing micro level environments resulting in a better chance for success.

The adverse win-lose mentality is linked to the liability-based contracts resulting in normative blame-based culture (meso – micro). Changes in the traditional contracts are needed; current contracts are developed assuming that everything works with tangible value e.g., either material or time. Additionally, traditional contracts inflict high liability and less or no rewards, therefore, reducing the likeliness that teams would go out of their way to make systemic change. However, there are barriers, in having shared risk and rewards in contracts; new tasks emerge such as open book accounting which involve administration and integration of financial systems that require members of the project level to be trained/educated. Another barrier depends on the fragmentation of the market; in a highly fragmented industry such as Finland, small roles can bring about increased complexity in project level risk when contracted with a shared risk and reward contract.

The traditional business model used in many construction projects involves the BIM process to belong to multiple firms which requires project level collaboration(meso – micro). The poor transfer of information between design and construction was also evident from the PM firm. On the other hand, firms that operate longer in the value chain report higher profits explaining that there is more integration in delivery. Integrated teams have also been linked to innovation success (Blayse and Manley, 2004).

Changing the traditional business model is clearly beneficial to firms and has been questioned in industry for a long time. However, the paradox is that there has been no sustainable change. For this reason, a public client in Norway is trying to disrupt the industry with consultants from the automotive industry. Firms explain the motives of controlling a bigger part of the project lifecycle in enabling easier implementation of innovation and increased profits brought about by more integration. However, this is possible in a limited number of projects in the private sector, most of the construction is done in the public sector where the traditional business model dominates. Contractors tend to invest in assets on their own becoming their own client directly dealing with the end user whereas consultants are moving towards managing both design and construction; moving from inter-organisational to intra-organisational collaboration. The polarised service nature of procurement and contracts is related to the reluctance of teams to trust each other (Bresnen and Marshall, 2000a). However, the increased risk of internal loss of control when involved in a larger part of the lifecycle was raised as a limitation by consultants.

The business model may have enabled differentiated levels of innovation where design firms tend to be the most innovative and the contractors the lowest. However, designers only

have a small part of the value chain, a public client representative from Norway puts across rhetorically that there cannot be a revolution from design firms although they are the most technically competent in BIM. This enables the question of whether disruptive innovation requires more equivalent innovation across the project lifecycle, brought about by a significant shift in business model.

Fragmentation of the 'service' providers further complicates the development of integrated teams that suit systemic innovation. Empirical evidence suggests that the contracts contribute to the fragmented behaviour of teams, this came across when comparing Alliance or IPD to traditional contracts. The 'interaction environment' between teams was related to innovation participation; more aggressive environments mean likely less participation or vice versa (Barrett, 2018). The fragmentation of contracts enabled by the fragmented industry can be claimed to enable the possibility of an aggressive interaction environment (meso – micro); traditional contracts makes this more likely than IPD/Alliance.

A limitation of the nature of systemic innovation is in showing short-term success which is difficult to measure; especially if the firm is only involved in some parts of the project lifecycle and developing innovation involves cooperation with other teams at the project level. The profit driven tendency of firms to see more value in investing and operating in a larger part of the lifecycle suggests that there is a misalignment of innovation and the business model. Furthermore, the lack of rewards in traditional contracts fail to incentivise inter-team innovative initiatives.

The incentives to collaborate do not exist, most contracts forcefully mention that teams are to collaborate but fail to mention any more detail. Contractual mechanisms to enable soft factors are suggested to depend on the client's understanding of the industry. The contractual effect on reducing bureaucracy, feedback of innovative ideas, identification of people to drive innovation are suggested in the literature (Asad et al., 2005). From empirical accounts, contracts indirectly incentivise teams to put their own interests at the forefront by failing to address the factors of collaboration (meso – micro).

Business models were compared; this resulted in differences in micro level factors and therefore differentiating behaviour. Where firms are paid by the hour, a higher quality deliverable is more likely, and vice versa with a lump sum payment. The behaviour towards the client is different in both contractual strategies, when they are paid by the hour, they tend to be more open to changes.

6.2.3.1.2 Team Selection

The selection of teams is a crucial part of procurement because of the non-controllable aspects people bring to the project that inflict consequences to project team chemistry and cohesion.

Keeping in mind that the relationships considered are between individuals (micro) rather than the organisations, the existing relationships between teams were found to be beneficial (Buvik and Rolfsen, 2015) to the PM firm (Study 1). If the same individuals are selected, the

benefits are driven by the past knowledge and experience of working with the processes and mentality that the lead firm utilises. The possibility of this occurring depends on the client and the policies that govern the procurement strategy; some clients who are publicly funded require an open tender which involves selecting a team-based on policy driven criteria. Relationship management in the form of alliancing and partnering is suggested (Blayse and Manley, 2004).

Even though participants see the benefits of procuring a team with other categories e.g., teams that they know, price-based selection is still dominant (Loosemore and Richard, 2015). Inevitably, the lowest price at tender stage rarely ends up being the lowest price at the end of the project phase.

Holistic understanding of the construction process appears to be important when selecting designers. With holistic understanding comes increased awareness of their own role and how it affects other teams at the project level. However, this cooperative attitude needs to be incentivised by the contracts.

A fundamental problem raised is in the discrepancy of information between the tender stage and the service provided. The individual's CVs provided at the tender phase appear positive but do not reflect in the project phase, therefore deeming parts of the selection criteria useless. Business ethics is associated with the roles of teams in industry and has its own stream of literature (Vee and Skitmore, 2003)

Regarding HP&C, a team leader with an open personality is preferred, likely resulting in more team openness at the project level. However, it also depends on the other team members, middle management can cause a bottleneck. An open attitude is preferred, however it was explained to not only be something that comes with a team but is also nurtured at the project level, depending on multiple factors (see Section 6.2.2.2).

6.2.3.2 Meso Level 2: Client Organisation and Needs

From the literature and empirical evidence, the nature of the client's involvement was found to be significant (Assaf et al., 2018). The lack of client knowledge and experience was found as a result of the inability to communicate their needs efficiently and understand deliverables (Loosemore and Richard, 2015). Literature uses equivocality to address this lack of knowledge (Engström and Hedgren, 2012). With more experienced clients, more efficient decisions are made resulting in a less risky project.

A consequence of poor knowledge and experience comes across in the low client trust. This results in the over-controlling attitude of clients towards contracts resulting in affected micro level attributes. Client trust towards project teams is required and can be exemplified by the use of contracts (Che Ibrahim et al., 2015). The client is responsible for making decisions regarding procurement and contracts, coupled with mistrust towards the PM could lead to inconsistent leadership in the project. In examples of scenarios of projects where clients control; contracts and procurement are developed with an over-controlling attitude as there is a common belief that the

building industry is all about making money described as opportunism (Van-Duren and Voordijk, 2015). Additionally, when teams are contracted to the client directly and a PM firm is appointed, it was made clear that the PM would lack leverage over teams appointed directly by the client.

The transfer of information between the design and production part of the construction process depends on the way the teams are procured and contracted which depends on the client's strategy. Data suggests that the procurement strategy that teams are selected using depends on the client's limitations, knowledge and experience. The client requires to believe in the benefits of choosing teams not solely on price but also based on the possibility to have positive collaboration and professional skills (De Araújo et al., 2017).

The hierarchy of the client organisation was found to affect the cognitive latency in making decisions; in more hierarchical client organisations (common in public clients), decisions are passed up the hierarchy driven by the fear of being held accountable. Furthermore, their reporting structure forces client representatives to make decisions suiting their culture of their firm e.g., cost control is given high significance. Literature shows the effect of client risks on project consultants (Kometa et al., 1996). Additionally, lack of client involvement and interaction with project level teams result in cognitive latency resulting from delayed/poor decision-making. This is representative in the Egan report that explains the need for clients to be encouraged to get involved (Egan, 2002; Loosemore and Richard, 2015).

If the end user is not the client, the nature of the end user market is connected to the client's behaviour and decision-making. The private sector involves more dialogue with the end user than the typical public project suggesting a macro level influence.

The client's behaviour is related to the financial aspects of the project which affects the collaborative attitudes at the project level in both literature and empirical evidence (Kometa et al., 1996).

The competency of the client should be more process oriented. Empirical data suggests that the client is to understand the need for early investment in processes (Pesämaa et al., 2018) that can add value throughout the construction phase suggested to be dependent on the relationships between the teams and the client; the typical traditional contract does not provide reward for innovation across the inter-organisational boundaries.

A more consulting attitude rather than an enforcing attitude is required by project teams (Kometa et al., 1996); an enforcing attitude brings about a fear to be open about innovative solutions. The client is to promote collaboration as part of their criteria for successful projects and not solely the financial aspects (Pesämaa et al., 2018).

6.2.4 Macro Level Factors

6.2.4.1 Organisational Culture

Organisational culture is a set of norms for behaviours in an organisation (Deshpande and Webster Jr, 1989). Organisational hierarchy is one aspect that contributes to the organisational

culture (Barnard and Simon, 1947). The more hierarchy in an organisation, the more challenges to innovation. This is suggested by Norwegian contractors who explain the difference in understanding of innovation between middle management and higher-level management. A greater hierarchy means less open interaction between middle and higher levels. Additionally, there were claims that the higher-level management perceive innovation like that related to BIM predominantly as a technical incremental change. This results in higher level management making unrealistic promises to clients and inefficiently allocating resources.

The influence of organisational culture was also evident from comparing public and private clients. The more hierarchy in typical public clients meant that they made decisions slower. Private clients are typically more business oriented. At the micro level, the macro level organisational influence is with regard to the norms set by the individual's firm that nurture the individual's decision-making process and behaviour. The value of the firm influences the individual's behaviour at the project level. This is evident from Study 1 where project managers explain that when dealing with a new team it takes some time for them to accept the mentality and culture of the project.

6.2.4.2 *Education*

The over-emphasis of technology in education rather than the softer aspects of collaboration was brought forward as partial reasoning towards the tendency to work in silos. Additionally, from Study 1, the effect of the divide in education between designers and production was suggested to impact the mentality of professionals resulting in micro level differences in mentality and attitude. Education suiting BIM is taking significance in research addressing this siloed nature of expectations instilled by education (Macdonald, 2012; Belayutham et al., 2018) as a consequence, to founding the way people think. The health care industry faced a similar challenge in the late 20th century, a reflection of their solution is provided in Section 8.2.

6.2.4.3 *Local Industry Culture*

Cultural expectations of behaviour were suggested to be different from geographical locations of industries resulting in differences in attitudes and disputes (HP&C – macro – micro). This is evident when a foreign firm starts working in a new industry, they require to adapt to the local culture. Safety cultures, openness about problems were also suggested to vary with geographical location.

6.2.4.4 *Change Management*

The effect of technological change towards BIM has brought about ease of changes in the model which was suggested to inhibit the attitude to consider another team's work. Additionally, it was suggested that the technology enables making design changes easier and therefore preventing changes without incentives, has become challenging. The service based nature of the industry driven by contractual norms (Dulaimi et al., 2002) could be impacting the motivation to cross the

disciplinary boundaries to ensure changes are made early in a collaborative and preventative fashion (meso – macro).

Idealising the optimal environment for digitalisation resulted in the need to change micro level attitudes in collaborative environments suggesting a lack of understanding of the problem. Motivations for teams to think holistically emerge as the suggestion from the PM perspective, however, how this can be done was still unclear showing the potential for further pedagogic research.

6.2.4.5 Standardisation

The mis-positioned focus of standardisation emerges as claims were made that the current focus was in the detail of building parts rather than in how the parts come together. This results from the discussion with contractors in Study 2 who explain the difficulty of using design models as the information is not structured optimally. The lifecycle inequality in standardisation; from BuildingSMART Norway, there are only 6% of members who are contractors, the majority are designers (BuildingSMART, 2019).

6.2.5 Human Psychology and Culture (HP&C)

In this section, the more foundational level added to the application of the external analysis model is as a result of factors that fit into all micro, meso and macro levels.

Psychological concepts are at different levels of abstraction (Hui and Triandis, 1985). This means that how specific a theory is, depends on the operational application and definition. In this context, findings suggest factors that are outside the original external analysis model (see Figure 48) defined under either micro, macro or meso. The HP&C factors affect all parts of the model and therefore are positioned more fundamentally related to a higher level of complexity coming from the way humans socialise and process decisions; human capability as the HFI defence policy explains (see Section 2.7.3). Therefore, representing a more abstract uncontrollable position in the model. Experts in change management and learning in organisations explain the need to consider the nature of organisations in the way changes are made:

> 'Sooner or later we'll all wake up and realise that the industrial system is a whole owned subsidiary of nature' (Senge, 1999: p. 8)

In this research, the micro, meso, macro is perceived as applied factors from the HP&C level which represents aspects reflecting the characteristics of psychology and sociology which inherently depend on human nature. To position the factors in this part of the model the following conditions are set:

1. Is the factor apparent in micro, meso and macro?

If the factor is apparent in all parts, it is as more fundamentally held in the model.

2. Is the factor relating to non-controllable factors that exist from cultural perspectives or human psychology?

Non-controllable factors emerge as a result of its dependency on the capability of human thinking and social interaction.

The following sub-sections provide evidence for factors positioned under HP&C considering existing literature. In the previous sections there has been a number of factors mentioned of HP&C, these have not been repeated in this section.

6.2.5.1 Psychological Comfort

If people feel psychological comfort they require being able to personalise and make their own decisions (Pineau, 1982). The effect of changing routines as a result of changes in process driven by technological advance results in the need for acceptance at an individual and group level. There is a loss of both capability to personalise and choose freely when a routine or process is new; it takes time to get accustomed depending on the individuals receptiveness to change. This can be applied in either macro, micro or meso factors. For example, in the micro level, the way that the process is defined in the project level (that the teams operate in) would impact how comfortable individuals feel with the change (Section 5.3.2.3.3). In the meso level, data suggests that the way that the contract incentivises a team to take on innovative/risky activities impacts the way the individual make decisions. In the macro level, evidence collected suggest that the local culture of the industry impacts what people are comfortable with e.g., in terms of openness, the expectations vary between teams and are evident when inexperienced foreign teams operate. In other words, people are comfortable with their own expectations of others.

> *'Two people looking at the same thing will learn two very different lessons'*
>
> *(Senge, 1999: p. 8)*

The findings also suggest that there is a personal characteristic based implication in the way an individual feels comfortable with a change in process; a more optimistic person would be open to trying something new or vice versa with a pessimistic person.

Psychological comfort was also related to the manner BIM is perceived and used, suggesting that more information gives them a bias feeling of safety resulting in a 'messy BIMM', further reiterating the need for lean fundamentals in the macro level. This means that positive psychological comfort can also represent inefficient decision-making.

6.2.5.2 Personality, Tendency to Trust/Mistrust (Personal Characteristics)

To apply personality to the model it was divided into two parts. The attitudes in the micro level was defined as the way that an individual's characteristics are applied depending on the project circumstance and environment. Findings suggest that the way people come across depends on the environment; i.e. natural vs nurtured characteristics. For example, from the findings, it is suggested that people with 'good' personalities can come across with 'bad' attitudes when put in such an environment.

In the HP&C part of the model, the personality is viewed as characteristics that do not change in the short-term (Lucas and Donnellan, 2011) and are applied in their most natural state in this part of the model.

The personality of an individual was also related to their ability to trust/mistrust suggesting that if a person has a mistrusting attitude, there is higher susceptibility to difficulties in collaboration; showing a link between the HP&C and micro level.

Personality formed a classification part of the Hannigan (1990) study of intercultural effectiveness. The ease of interaction styles and personality factors was found to be important. Furthermore, a patient, courteous, flexible attitude allowing a willingness to immerse oneself in the new environment is required (Hannigan, 1990).

6.2.5.3 Cultural Expectations, Openness, Trust

Findings suggest that the expectations of openness vary depending on the local culture of the team's normative operations. From both Norway and Finland, openness is highly valued and expected. Processes and project level developments are conducted on the basis of 'what is normal' which means that when a team is not experienced in the local culture, friction was found to exist. The positioning of cultural expectations as part of HP&C was backed by its application in all the parts of the model. At the micro and macro level, behavioural aspects were related to the expectations of the culture that the foreign firm was from. From studies on leadership, it was found that leaders behave according to their societies' expectations (Dorfman, Hanges & Brodbeck, 2004: p. 511; House *et al.*, 2013: p. 324). At the meso level, the cultural expectations resulting from the client organisation was found to change the way decisions were made at the project level.

6.2.5.4 Motivation

Motivation was found evident in all levels, therefore as per the rules set of the model, it was a foundational aspect. In literature, there is a dominant oversimplification relating motivation to incentives and performance (Bresnen and Marshall, 2000b). At the micro level, responsibility to project level participants to develop the Information Delivery Strategy was related to increases in intrinsic motivation. At the meso level, the shared risk and rewards in contracts showed improved motivation, project level participants are more likely to go beyond their formal roles to improve the design solution. Since project level participants are hired by firms contracted by the project, the individual motivation has dependency on organisational factors in the macro level. The complexity of the motivational aspect is further discussed in Section 8.3.2.1.

6.2.5.5 Holistic Understanding

Holistic understanding differs from holistic thinking, even if holistic understanding exists in an individual it needs to be incentivised into practice (holistic thinking) at the project level. Holistic understanding is limited by the siloed nature of education and its use is restricted/alleviated by

the nature of procurement and contracts. The individual's holistic understanding was suggested to develop from experience. Furthermore, the use of holistic understanding was found to be enabled by working with teams that utilise holistic thinking enabled by an open-minded leader. Holistic thinking is evident in design solutions' precision at early stages of the design process; if the solution is overly precise, it is likely that the designer is not motivated to think holistically. With regards to BIM, holistic understanding is the contextual understanding of technical models which experts have; the technical aspects are only a part of the overall deliverables of a construction project. However, since they are tangible, they are given overestimated value.

6.2.5.6 Normative Practices and Behaviour

Regardless of construction organisations claiming that they encourage innovative and creative behaviour, many are unable to do so. Pech (2001) explains that this may be due to the high need for conformity amongst organisational members, although it helps group cohesiveness it can stifle creativity as there are norms to stand by to ensure group membership. The habits and routines of practitioners are normative practices, these routines are being challenged by digitalisation enabled changes in delivery. However, people are often comfortable with their normative behaviour and practices and therefore brings dependency on personal characteristics and the way their organisation manages change.

Price-based selection is a dominating normative practice. Clients are found to believe that the normative practice is for teams to make higher profits at the loss of the client. Disciplines all have normative practices independent of one another.

6.3 Summary

This chapter presented empirical evidence and literature to ground the suggested external analysis model. Figure 51 and 52 summarise the interactions between factors found in Finland and Norway. The complexity and interdependence of factors reiterates the need for better holistic understanding of the nature of knowledge that contributes to a collaborative inter-organisational team environment. Although all parts of the model were treated with equal significance, the lack of systemic industry wide impact in micro level changes and lack of controllability in macro and HP&C levels results in paying attention to the meso level (the most practically impactful and changeable level). This section provides a summary of findings and literature of the meso levels which are taken forward to a significant part of the discussion in Chapter 8. Table 19 provides a summary of the empirical factors found concerning Meso Level 1 whereas Table 20 shows empirical factors found concerning Meso Level 2. A judgement of controllability of the interacting factors in each finding is made. A high controllability means that the project manager can control it, medium means the project manager has some influence and low means the project manager has nearly no influence. Chapter **Error! Reference source not found.** provides the expert views on these empirical issues.

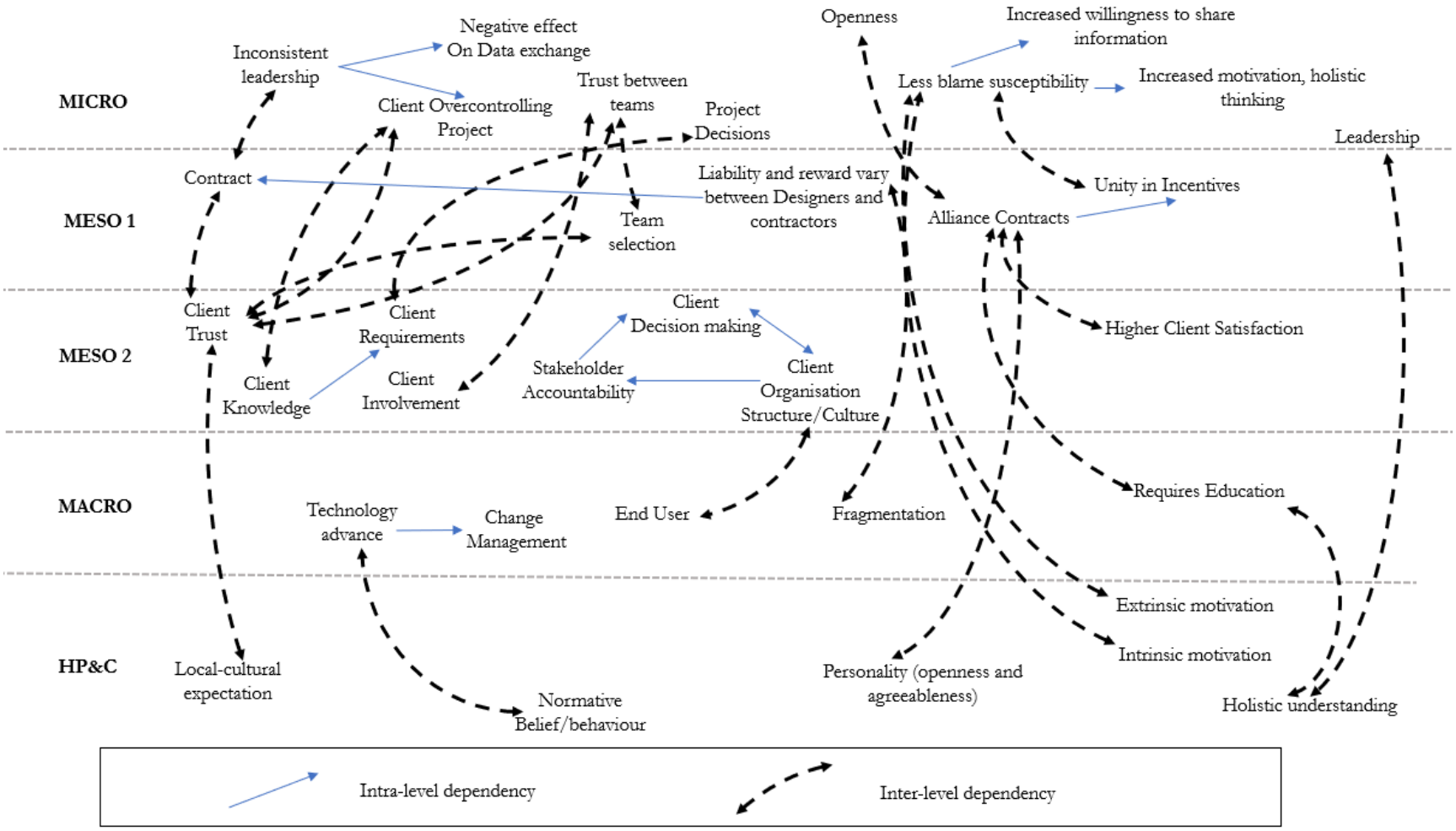


Figure 51: Summary of Interactions from Finnish Case

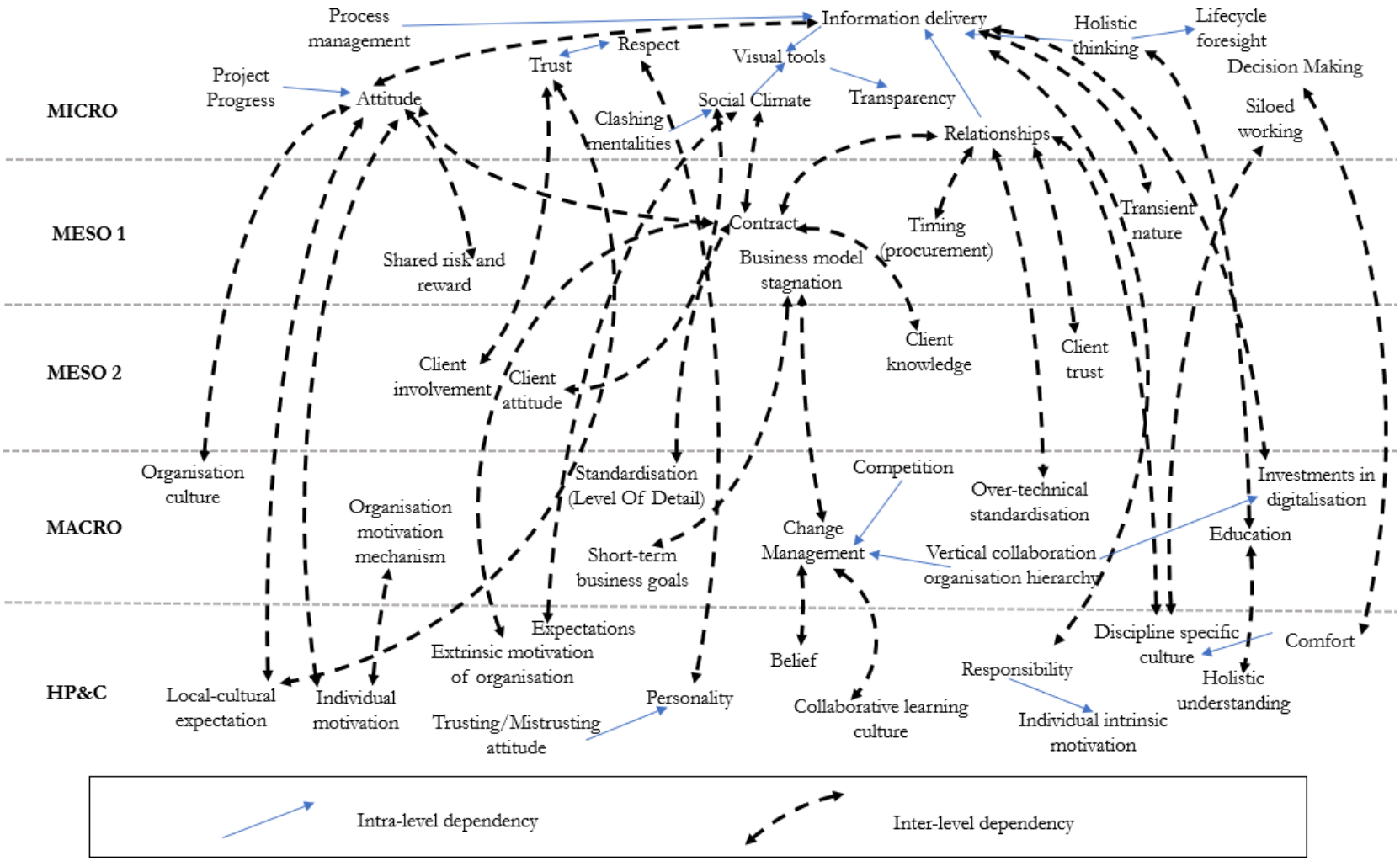


Figure 52: Summary of Interactions found from Norwegian Case

Table 19: Summary of Procurement, Contract, and Business Model Issues (Meso Level 1)

Empirical Critical Factors	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	Key Literature associated
Misalignment of business model and digitalisation inflict different project level behaviour	Contractual setup to incentivise innovation beyond professional boundaries	**Medium**	Contractual setup incentivises definition of professional boundaries	Lower impact in reducing information latency from a holistic point of view as teams are not incentivised in ways to suit digitalisation through the entire lifecycle	Digitalisation using e.g., BIM is systemic and long term, contracts are much shorter in timescale, meaning that teams have to be willing to work on and in ways that is outside their scope suiting each other's and the project's overall needs.	Blayse & Manley, 2004; Walker & Hampson, 2003
Heavy liability contracts, lack of rewards – sharing liability and reward	Rewards for innovative action is shared, liability is shared	**High**	Individualistic contracts, Low/No rewards for systemic innovation, high liability contracts	When shared risk and reward, reduced cognitive latency as sharing information is perceived as less risky. If high liability, information sharing can increase susceptibility to negative collaborative behaviour	Liability in contracts inflict people to stay within their comfort zone to ensure they do not lose; this comfort zone is defined by the fragmentation of the market. Lack of rewards do not incentivise team to step out of comfort zone as needed by innovative actions.	Khosrowshahi & Arayici, 2012
The service mentality – the need for investment mentality	Teams are incentivised to invest in learning and adapting to best suit the project	**Low**	Teams work individually and try to meet the requirements	Service mentality increases information latency by reducing the unity in lifecycle goals	The 'I do my part and you do yours' mentality driven by individual contracts treating teams like a service keeps them from investing into the long-term goals of the project.	Bresnen & Marshall, 2000

Empirical Critical Factors	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	Key Literature associated
Industry fragmentation	Building long term partnerships between small firms to reduce the risk on one firm	**Medium**	Fragmented individualistic contracts	Fragmented individualistic contracts incentivise varied motives and lack of unity in goals therefore increased susceptibility to IL	Traditional treatment of fragmentation means more individual contracts. More individual contracts would bring more individualistic goals and more probability of win-lose mentality	Barrett & Sexton, 2006
Differentiating innovation in project lifecycle	Innovation is developed equally across the project lifecycle	**Low**	Innovation is developed differently in a fragmented fashion, reducing the systemic impact	Skills, motivation, expectations of information delivery varies throughout the lifecycle suggesting that IL exists between project phases	Siloed nature of education, differences in profession-based culture, software capability, etc.	Blayse & Manley, 2004
Contractual nature of addressing collaboration	Collaboration is not expected/forced but encouraged by e.g., informal activities with the client	**Medium**	Collaboration is expected and there are few/no systems to incentivise it	IL reduces with effective collaboration which can be incentivised	Collaboration is not valued by all, the culture is to work in silos which is perceived as normal, inhibits impact of digitalisation. Transformation of contractual needs to lower level successful collaboration is lacking.	Asad *et al.*, 2005;Buvik & Rolfsen, 2015

Empirical Critical Factors	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	Key Literature associated
Non-relationship focus of team selection	Relationships are prioritised over cost	**High**	Teams are selected mainly by cost	Positive relationships mean better understanding of each other reducing the susceptibility to cognitive latency. Relationship management by the use of partnering can increase team cooperation and therefore more likely reduce IL	Human factors are non-tangible, lack of awareness of significance, people are technically educated	Blayse & Manley, 2004; Kumaraswamy & Dulaimi, 2001; Buvik & Rolfsen, 2015
Discrepancy of tender information and reality	Tender information is team-based and verified when awarded	**Medium**	Tender information is not verified when contract is awarded and focuses on the organisation	IL is more likely to be uncontrollable when the expectations set at tender stage are not delivered.	Business ethics inadequately addressed by the industry, lack of verification of information at tender stage	Vee & Skitmore, 2003
Non-personality/team chemistry based selection	Teams are selected based on real life informal events to understand chemistry	**High**	No human factors are considered as tender bases information on organisation not the specific team	Higher likeliness of lacking team chemistry and trust can impact cognitive latency and increase the number of iterations of information flow	Natural characteristics are important, trust cannot be created even if incentivised in some cases. Lack of awareness of human factor and application of social science and psychology methods to understand chemistry between teams.	Buvik & Rolfsen, 2015

Table 20: Summary of Client Related Empirical Factors (Meso Level 2)

Empirical Critical Factor	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	How it can be controlled	Key literature associated
Client technical knowledge	Client Representative is able to understand information in the manner that it is produced	**Medium**	Client Representative requires a different form of information to enable complete understanding	Equivocality influencing client driven decisions negatively. If the client requires a simplified form of information, this adds more pressure on the teams; higher technical latency	Not incentivised and lack of awareness of importance in client firms	The involvement of an independent consultant bridging the gap of technical competency	Hedgren & Stehn, 2014; Engström & Hedgren, 2012; Neill & Rose, 2007; Rachel Dinur, 2011; Levander *et al.*, 2011; Daft & Weick, 1984;
Client perception of industry culture	Client does not think the players are solely driven by individual profits	**Low**	Client decision is affected based on assumptions such as firms are driven by capitalistic and opportunistic goals which creates lack of trust between teams and client	Negative influence on client decision-making driven by heuristic based assumptions stemming from local industrial culture or past experience. Poor decision-making results in higher probability of technical latency	Long term traditional values running culturally in client firms; internal policies of client firms which are set to make the Client Representative think about cost control in a fixed manner resulting in lack of client trust	Leadership strategies to make openness of finance critical in the contract, develop trust from the beginning of the project; rewards to teams that reduce cost drastically	Boukendour, 2007; Van Duren & Voordijk, 2015
Hierarchy of client organisational culture	Hierarchy in the client organisation does not influence Client Representative; sufficient	**Low**	Long process in decision-making as decisions are passed up the hierarchy	Judgement/response selection delay as Decision-making is slowed down, therefore creating a breakage in the flow of information	The Client Representative is contracted to the client organisation in a way that inflicts personal liability, Client Representative is in a position where	Awareness to client organisations	Schneeweiβ, 1995; Kometa, Olomolaiye & Harris, 1996; Barnard & Simon, 1947

Empirical Critical Factor	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	How it can be controlled	Key literature associated
	freedom to make decisions				faults can be traced back and made public		
Client involvement in contract development	Trusting the project management enough to give them leverage over teams	**Medium**	Client wants to be in the position of power, which puts the project management in a decentralised role	When the leader has lower leverage to other teams, teams are prone to deliver information not on time or lacking in quality.	If the contracts are direct to the client, there is risk of the client not having sufficient knowledge to make decisions. Financial leverage to the project management firm allows for control over the other teams	Open dialogue between the client and the project management when developing contracts early in the project progress	Che Ibrahim, Costello & Wilkinson, 2015
Client perception of own role	Client understands that there is need for high involvement and interaction with teams	**Medium**	Client only considerate to financial issues	If the client is not involved optimally, cognitive latency can emerge from delayed/poor decision-making	Client's involvement is vital to the team's motivation and their own understanding of processes that teams utilise to interoperate	Project management to raise awareness to the client of the need for consistent involvement throughout the project	Loosemore & Richard, 2015; Thompson, 1991; Egan, 2002; Rajakallio *et al.*, 2017
Client knowledge of own needs	Client's needs do not change through the process of design and construction	**Low**	Client needs constantly evolved putting pressure on teams to provide solutions systemically, bringing	More information flow due to extra work, repetition of tasks reduces motivation, therefore higher probability of latent information	The client needs affect the client requirements that teams are developing a product for, therefore, if the requirements consistently change,	Client to use forms of virtual reality to understand what is needed	Loosemore & Richard, 2015; Kometa, Olomolaiye & Harris, 1996

Empirical Critical Factor	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	How it can be controlled	Key literature associated
			uncertainty of extra work claims in accordance to the contract		this brings inefficiency		
Clients influence on team selection	Client oversees team selection in a transparent manner with the project management	**Medium**	Client selects teams without consulting project management	The non-optimal selection of teams can bring about lacking trust and motivation, teams do not have the skills and characteristics to interoperate;	Team selection is critical in ensuring that teams can interoperate efficiently with the skills, personality and experience they have	Client to trust the project management to enable an open procurement strategy not only based on skills but previous experiences	Che Ibrahim, Costello & Wilkinson, 2015; De Araújo, Alencar & de Miranda Mota, 2017; Briscoe *et al.*, 2004; Kometa, Olomolaiye & Harris, 1996; Loosemore & Richard, 2015
Client financial stability and flexibility	Client is able to finance major changes to the budget mainly due to changing client requirements	**Low**	Client changes requirements with insufficient financial flexibility	Lack of motivation as the finance is not flexible enough to take on the changes requested; susceptibility to IL	The lack of financial flexibility can bring about less motivation to teams when the client requirements change as they question whether they can be paid as agreed. Extra works claims can be rejected	Leadership to plan the financial part of the project with more contingency if client needs will change and if the client is less financially flexible	Kometa, Olomolaiye & Harris, 1996
Client attitude	A more consulting attitude	**Low**	An enforcing attitude	A client with a consulting attitude can utilise teams to	The client's attitude makes the consultants	Awareness to client organisations	Kometa, Olomolaiye & Harris, 1996

Empirical Critical Factor	Success Characteristic	Control-lability	Failure Characteristic	Effect on Information Latency (IL)	Possible Reasoning	How it can be controlled	Key literature associated
				make suitable decisions to reduce risk of IL	fear to be open about innovative solutions		
Client perception of early investment on processes	Client accepts early investment on processes understanding that information delivery can be streamlined for future benefit in the project	**Low**	Client does not see the value in early investment on processes	More streamlined processes allow for faster generation of information and therefore less technical latency	Processes like scripting of repetitive tasks can be done to reduce the time taken and human resources allocated	Client to improve understanding of technical aspects in the end to end construction process	Hedgren & Stehn, 2014; Simon, 1965; Collins, Parrish & Gibson Jr, 2017; Luo *et al.*, 2016; Chang & Chiu, 2005; Loosemore & Richard, 2015; Briscoe *et al.*, 2004; Pesämaa, Larsson & Erik Eriksson, 2018
Client's criteria for success	Client promotes collaboration as part of their criteria for successful projects	**Low**	Client focuses on financial criteria for success	Positive collaboration can improve information flow in numeral ways both cognitively and technically, enabled by increased openness	Client demands are treated seriously by teams employed and therefore would make collaboration important	Awareness to client organisations	Karen & Le, 2015; Babaeian Jelodar, Yiu & Wilkinson, 2016; Pesämaa, Larsson & Erik Eriksson, 2018; Kometa, Olomolaiye & Harris, 1996; Loosemore & Richard, 2015; Briscoe *et al.*, 2004

7. EXPERT INTERVIEWS AND THEORETICAL APPLICATION

7.1 Introduction

This chapter aims to validate the interpretation of findings; whether the model and theoretical application is consistently aligned with reality. The motivation is to understand whether the bias of the researcher and/or participants could have misaligned interpretations and to locate gaps in the data collected. The objective of this chapter is to validate the model and meso level centred empirical findings by the use of expert interviews and existing literature (SRQ6).

The model's structure was verified by experts and literature, making additions to the model or suggested changes to enforce clarity (see Section 7.3). The logic and conditions of choosing the meso focus to apply theory was validated. Additionally, the observed issues and problems associated are confirmed/disconfirmed with respect to expert views and literature.

Interviewing experts resulted in the emergence of gaps and discrepancies with empirical evidence from Studies 1 and 2; expected due to the impact of participant bias. Many of these gaps and discrepancies (see Section 7.4) are attributed to the inability of project level practitioners to express the root causes of collaboration challenges, experts were more strategic and experienced in human factors. Therefore, almost all these gaps can be related to factors that are within the model at a lower level e.g., business ethics was found as a deep-rooted cause of lacking organisational transparency in hierarchical organisations.

The approach in the expert interviews was conducted in a semi-structured (but flexible) manner, where rooted factors were confirmed as important using open questions (as shown in Appendix H). Experts 1, 2 and 5 were strategic members of organisations whose focus was on developing effective project definitions (micro); symptoms of underlying cultural aspects emerged more frequently. However, these experts were in the position to talk about concerns of the industry rooted to e.g., social well-being and business ethics. Experts 3 and 4 had a psychology background in addition to practitioner experience and easily expressed the cultural aspects; they had a higher focus on underlying causes rather than symptoms. However, the symptoms are respective of the causes; validating the nature of the model that has emerged in this research as symptoms at multiple levels are as a result of fundamental causes rooted in the Human Psychology and Culture (HP&C) level.

Section 7.5 provides views from expert and literature about the meso level empirical issues/problems. Section 7.6 discusses the validation outcome and Section 7.7 provides a summary and an updated version of the Holistic Model for Collaboration in the AEC industry (HMC-AEC).

7.2 Expert Interview Participants

This section presents the background of the experts. The expert participants were all recruited using convenience sampling by the researcher's access to the UK AEC industry via networks of supervisors and advisors. Table 21 shows a summary of participants' backgrounds. The selection criteria involved the following requirements:

- Recent experience in the AEC industry (<10 years ago),
- Involvement in firm/industry strategy and/or a background/knowledge in psychology/human factors in relation to the AEC industry,
- Experience in a similar industry (desirable).

Table 21: Expert Participant Background

Expert Interviewee No.	Description of History and Current Role	Educational Background
1	Held roles in industry since 1998: Design supervision engineer, on-site supervision, quality manager, health and safety manager, performance management. Currently involved as a quality and handover manager building strategy to achieve operational excellence; lean efficiency, quality, proactivity.	Engineer
2	Held roles working as an engineer for a contractor, strategy development with the UK government, information and digital management for a contractor. Currently a global BIM director for a multinational firm. Involved in developing company and industry wide strategy for digitalisation.	Engineer
3	Human factors specialist, previously worked in the Defence industry conducting research, maritime industry research in human factors, environmental resource management involved in developing human factor strategy internally. Currently a human factors specialist working as a consultant in the AEC industry.	Psychology (Human Factors)
4	A landscape architecture practitioner who was intrigued by the role of human factors in collaboration, holds a master's in social psychology and continued to do a PhD investigating collaboration between design teams.	Landscape Architect/Social Psychologist
5	Director of a consultancy firm, manages a group of 25 design managers, educated and experienced as an engineer since 1989. Experience working with quantity surveyors.	Architectural Engineer

7.3 Validation of HMC-AEC and Meso Focus

An external analysis model (micro, meso, macro) utilised to structure the model was validated by a number of applications the scenario typology is used in organisational and CM literature (Van Notten et al., 2003; Moum, 2008). However, factors and aspects that fit in all parts were classified under a more foundational level (HP&C). The Human Psychology and Culture (HP&C) level

refers to the factors that affect behaviour based on the way people think and socialise; it is inherently closer to the nature of human behaviour. This rooted dependency is also supported in research conducted by Barrett (2018); the evidence showed that social psychological aspects affect decision-making.

Studies 1 and 2 suggested that effective implementation of digital tools requires micro level traits that suit strong individual trust and relationships in an open environment. As shown below, experts confirm this need for strong relationships. The relationships emerge from the lower levels in the model validating the hierarchy.

> *'that structure then is what enables the behaviour to emerge and so this is another theory that I often talk about which is human behaviour is emergent based on the context or system that I am within so having all of these, you've got policies, you've got change management, you've got process management, you've got contracts, all of those will affect my behaviour so having them at the bottom is good, I like that and then the one you've got relationship, trust, openness, so those are emerging factors of the structure, so my openness is dependent upon I guess the culture that am in, policies that are there, those sorts of things, and that affects my attitude, that affects my relationship' (Expert 3)*

The experts interviewed were asked open questions about the most emergent themes from Studies 1 and 2. Experts confirmed multiple factors that affect the way decisions are made at the project level, of which, the meso levels were confirmed as playing a vital part in the transactional level that either restricts or alleviates culturally normative behaviour. However as Strahorn, Brewer and Gajendran (2017) justifies, the meso level aspects are not the only parts of the model which require change to suit effective implementation of digitalisation and positive collaboration. However, to enhance the focus of the research outcome, the meso level was the focal point (see Section 6.2.1). With validated empirical evidence, this allowed further association with theories from psychology to understand the meso level effect on project level decisions; representative of the transactional part of the external analysis model.

Limiting the scope of the theoretical application to the meso level was indirectly backed with respect to the structure of the model. The expert used the 'changeability' to describe the practicality and impact of making changes; reiterating the need to focus on a level that is practical and achieves systemic impact:

> *'it's about how changeable it can be, I can change how I feel about somebody on a day to day basis I can change how I behave or think about myself on a day to day basis <pointing at micro>, these things I can't change, I can't change how I was educated, I can't change my human nature <pointing at Human Psychology and Culture>, well I can change a bit but not too much, I'm getting too old for that. But they are some things I just can change so well on a daily basis but my client can change every 18months or so <pointing at meso levels>, my education I can change if I do another degree or do a PhD, but how long is that going to take me? <macro> Human nature that's going to take a lifetime to change so there's a time thing as well here. And to change culture will take about 15years I reckon 10-15years I suppose. To change behaviour?' (Expert 4)*

Although the expert does not explicitly explain that meso levels should be focused on, the assumptions made to select the meso are supported (see Table 18). Literature also suggests that the client, contracts and procurement route play a vital role in promoting innovation and collaboration within construction (Blayse and Manley, 2004; Asad et al., 2005; Barrett, 2018) although it is recognized as not the only aspects that affect collaboration; requiring the holistic understanding brought about by the model and research approach.

Deep *et al.*, (2018) studied procurement risk allocation and collaboration and found that the symptoms from the project level behaviour e.g., opportunism, lack of trust came as a consequence of the client's interests; externally validating the model's structure that the client meso level is more foundational than the procurement and contracts meso level.

Regarding the 'impact of change' in each of the levels, experts agree that the micro level changes would not replicate into other projects, it is more impactful to change embedded aspects that affect multiple projects e.g., contracts. The meso level is the most ideal level to make changes also because macro and HP&C are not easily controllable.

> *'you might improve something on a single product that doesn't mean it's going to improve for the next project that those people will do, so if you get something embedded it's much more likely to impact…and then also controllability you can't go to the organisational level because, well you can but it's much harder because it involves a lot more people to make that change… making sure that you apply them to all the projects that you do depends on the project definition' (Expert 5)*

Literature also confirms the behavioural nature of inter-team innovative processes that are effective in a positive collaborative project environment:

> *'The process of innovation is behavioural in nature, being a cyclical process of diagnosing, action planning, taking action, evaluating and specifying learning' (Barrett et al., 2008, p.342)*

The defence industry utilises Human Factors Integration (HFI) as part of their regulatory process. In the model they ground the regulation to the 'environment', it is explained that:

> *'The design and realisation of the solution should make best use of human capabilities (physical, cognitive, psychological and social characteristics) and should provide mitigations for human limitations' (Ministry of Defence, 2015b)*

Similar as proposed by the emergence of the adapted external analysis model structure, it is inevitable that the people, tools and process part of the model require grounding to human capabilities and limitations. Barrett (2018) conducted an explorative study of design team collaboration and developed a framework that also found AEC based themes. The study confirms findings that factors and issues regarding collaborative behaviour are rooted in psychological and sociological aspects. This research takes this further to apply the Theory of Planned Behaviour (TPB) showing that beliefs are the root causes of the way decisions are made and applies a hierarchy to AEC based themes.

7.4 Gaps and Discrepancies Raised by Experts

Table 22 shows the gaps in Studies' 1 and 2 data according to experts. Six out of the ten gaps are related to the HP&C foundational level of the model. This signifies a critical difference between the experts and the Studies' 1 and 2 participants; experts are more capable to relate symptoms closer to root causes of project level factors.

Table 22: Gaps in Studies' 1 and 2 Data According to Experts

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
1	**Continuous learning culture**	Reflection of experiences in tangible forms for continuous improvement of delivery of solutions is lacking, this is not a cultural norm in the industry. Informal information as from original studies are not used effectively.	'This idea that me having all this stuff in my head about things that have gone right and things that have gone wrong is great but if we can capture it… then it's about that knowledge transfer. So, I would say from a AEC industry point of view what we are really terrible at capturing lessons and learning from them' (Expert 1)	Education, (Macro) - Cultural expectation of process (HP&C)
2	**Business ethics**	Business ethical is questioned as a result of the lack of transparency, the lack of transparency was brought up in Norwegian contractor focus groups, however, this was not related to business ethics.	'Carillion has completely changed the way that people actually view things and ever since Carillion happened...I would say that fear of failure but also the fact that people too often have tried to hide behind the fact that they have not feasibility of stuff and there hasn't been transparency... I would say it's more basic than that, it's actually fundamental lies, its business ethics that's what's caused a lot of issues' (Expert 1)	Business ethics (HP&C) – Organisational culture (macro)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
3	**Early data exchange process design setting and belief**	Setting the processes by which teams operate goes beyond just how they share information but also how they make decisions, training is also needed to allow individuals to gain understanding of the processes	'… for them to take an hour out of the day to go and learn how to use a system where they could get it done using the methods that they previously used… at the start of the project it's very important where they haven't broken ground yet, this is the system we are going to use, let's all train up on it and these are the processes these are the ways that we are going to collaborate, these are your priorities, that sort of thing will kind of, I guess easier to implement' (Expert 3) 'in terms of delivery I think it's more to do with if you've got the processes in place and people believe it, there's a good training, if there's a good communication around what that strategy looks like, people will follow it' (Expert 1)	Project definition (Micro) - Belief in processes (HP&C)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
4	**Personality needs of project vary through lifecycle**	The amount of e.g., creative traits of teams varies throughout the project, personality needs are variant depending on the needs of the particular phase	'I think it really influences the trajectory project. I did an experiment ages ago with people in practice and I made some teams, this was at the height when I was exploring the idea of the personality clash, so I made some teams, I did some psychometric, so I made some teams that had deliberate clashing personalities, I made some teams that should work beautifully and actually you would find that certain teams were better at certain stages of the project. So we are looking at the project as a whole when we should be looking at personality at different stages cause I found that the personality clash team were better in the creative early concept stages, they came up with lots of ideas but they couldn't deliver them, whilst the really balanced team couldn't come up with any ideas, they came up with one and everyone agreed and they delivered it absolutely beautiful, time, cost, quality everything perfect' (Expert 4)	Micro – Personal characteristics (HP&C)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
5	**Social well-being**	Presents a symptom of the effects of digitalisation enabling higher fragmented delivery of information. This is linked to negative mental health/social well-being and therefore can be associated with decision-making at the project level.	'actually the collaboration bit was very strong on <project> because we had an occupational health nurse on site we talked openly about stress and mental health and actually it's only when you have trusting relationships and you deal with people … a big part in here about leadership, about culture, about motivation, about organisational culture, about stakeholder accountability, about education, all those things for me tie in around what we've just talked about, social value, Electronic data interchange (EDI), social well-being, health and well-being' (Expert 1) 'it's a well-being health issue, mental health project but my work looking at the digitalisation stuff is kind of saying hold on, there's a workplace loneliness issue evolving the introvert guy looking at his three screen at home emailing and taking part in the BIM project but not actually reporting in for work a number of organisations are downsizing their offices so there are not enough desks for the number of employees and people do work from home cause it saves them money' (Expert 4)	Technological change, Corporate Social responsibility (Macro) – Social Well-being (Human Psychology and Culture)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
6	**Empowerment**	Giving individuals the ability to make decisions in a systematic manner	'I empower the appropriate people to make the decisions' (Expert 3); 'A big part of what they used to do was that people felt empowered as they did in Toyota there was what was called the red string, so if you say anything on that line that you were not happy about, everybody was empowered to be able to stop the production line, they would have 20 minutes to figure out what the problem was before they had that car taken out of production line, so a big part about failure is about empowerment' (Expert 1); 'Again, if they are not empowered to be able to make decisions then they are not going to be able to make decisions' (Expert 4)	Empowerment (HP&C)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
7	**Delegating trust and responsibility**	The need to delegate accountability, consulting actions, responsibility, informing actions in a structured form. In majority of projects, these are left to the project leader, and is highly centralised with roles left unclear.	'to me it almost felt like responsibilities and authority matrix rather than trust and this is truly important in projects, it's called RACI and it stands for Responsible, Accountable, Consulted and Informed and basically it is the way that the project is set up for decision-making. So, who's responsible for doing what activities, for making what decisions, who's accountable because they can be different, who needs to be told and who needs to be asked their opinion, to delegate authority and to delegate that trust… 'I trust' can be quite an emotional concept and this is a way to I guess to put it down on paper…I could trust you, I think you might be a great guy and make great decisions but I will need to empower you and give you the authority you need to do it. So, for me they are very closely related those two things...' (Expert 3)	Project Definition (Micro) – Trust (Human Psychology and Culture)
8	**Collaboration through the hierarchy (vertically)**	Internal firm collaboration is important and depends on hierarchy, the hierarchy influences decision-making empowerment	'a hierarchical organisation has a big impact on how an individual collaborates in that team and the initiative that they are likely to take ' (Expert 3); 'to have the level of granularity that you need to be at the top to be able to make informed decisions it needs information and data from the bottom so that's where I think in the last 18 months to 2 years, we are getting much better at the data at the bottom which has been able to get that level of granularity so you can kind of pyramid it up' (Expert 1)	Organisational structure (Macro) – Motivation (HP&C)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
9	**Tribalism**	Individual impressions of a person affect decisions made towards them and their role. Individual impressions are said to depend on stereotypical views. People with similar mentalities and interests form groups which affect their mental perceptions towards other groups and therefore affects project level decision-making	'someone is being picked on because of what they wore and they were objectively sitting it all just came out like a banter, you know I was just messing with you but I'm actually observing it and it made me feel uncomfortable it was not nice and it was making the other person feel excluded to a point where they stopped coming for meetings and that was evidence that they felt excluded. And it came down to the fact hearing their conversations that they didn't like what he did and that he worked too slowly and that he wasn't really on the same page as everybody else but objectively I didn't think that that person had technical competence issues but I think he just had different motivations but it was perceived as technical, he was doing the project differently... his personality just put him in that position I think that could have been managed but it wasn't and they lost some technical expertise by him leaving the project' (Expert 4) 'There is a bias… against those people who don't conform to a typical view not just gender or culture or whatever else is just problematic and that just comes out of how people are just excluded, and they are not even noticing that they are being excluded. It's like what I see on those with the drinking culture they exclude a lot of their colleagues and just non awareness of just organizing events around different religious festivals and that's just non acceptance of difference I think … the same acknowledgment of it isn't there so I think they are still a lot of biases there on the white middle class male stereotype thing I think that has to be the biggest one' (Expert 4)	Tribalism, personality (HP&C) – Relationships (Micro)

	Gap	Explanation	Expert Interview Evidence	Perceived Interaction in the HMC-AEC
10	**Trust is not only between individuals, trust in the systems that govern processes defined in a project, expertise.**	Trust in Studies 1 and 2 emerged predominantly as between individuals. Trust is to be in the systems defined and the capabilities and professionalism of the collaborating teams	'… what I was referring to there in terms of trust commercial meaning of trust, I mean the client and the construction company. In terms of collaboration that's probably different, because trust is quite closely tied up with respect and if I need to respect and collaborate with you I need to I guess respect your ability but also trust that you respect mine, we can have that collaborative relationship and if I don't trust that you have the expertise that you say you do then am not okay, it's wasting my time or I might have to do extra work or you are going to go and make a decision behind my back. So, I think on a 1 to 1 level of collaboration trust is extremely important and that is something that can be dealt with I guess structurally through job descriptions, job role through expertise requirement… I guess for the client...recognizing or believing that the construction company is going to do what they said they would do or that they have the ability to do it, so I think commercially there's going to be a contract involved' (Expert 3)	Trust (Micro, Meso, Macro therefore HP&C)

A discrepancy was indicated by experts; trust requires being more fundamental in the model as it affects all micro, meso and macro levels. In the main study, the emergence of trust only in the micro level could be attributed to the nature of participants being highly technical and non-strategic without the ability to draw distinctions between trust individually and in other levels. Furthermore, it could be a flaw in the analysis of the data by the researcher.

Experts also highlighted differences in the definition of human factors. In this thesis, the analysis is done with the assumption made from the point of departure on the basis of the IDDS model (Figure 1). The IDDS model consists of people, process and tools simplified to one level, with non-human parts of the process and tools. However, the human factors definition below shows that the people/human element grounds the tools and process parts. In the defence industry where human factors are highly regulated, human factors are defined as:

> *'… a scientific and engineering discipline that is concerned with the study of human capabilities and limitations, human interactions with technologies and environments and the application of this knowledge to products, processes and environments' (Ministry of Defence, 2015a, p. 1)*

From the above definition, it can be justified that the entire model in this application can also be referred to as human factors. Therefore, in order to ensure consistency, it is important to note that human factors in the analysis of data are defined in a manner that is respective of individual psychological/cultural factors and not as a collection of factors in defence.

7.5 Validation of the Meso Level Factors

7.5.1 Validation of Meso Level 1 from Experts

Table 23 shows meso level 1 factors established from Studies 1 and 2, open questions based on these issues were made to seek expert confirmation/disagreement or elaboration; thereby enhancing the clarity of the existence of the issue in relation with other factors within the model.

Table 23: Meso Level 1 Empirical Factors Expert (Dis)Confirmation and/or Elaboration

	Empirical Critical Factors	Possible Reasoning	Key Literature Associated	Expert (Dis)Confirmation (if any)	Missing or Elaborated Aspects
EI 1	**Misalignment of business model and digitalisation inflict different project level behaviour**	Digitalisation using e.g., BIM is systemic and long-term, contracts are much shorter in timescale, meaning that teams have to be willing to work on and in ways that is outside their scope suiting each other's and the project's overall needs.	Blayse & Manley, 2004; Walker & Hampson, 2003; Barrett, 2018;	'people are operating and kind of have a dual personality that they bring to the table about the team that their organisational culture by being a little bit different it particularly came out when it was about the tensional relationships about profits and innovation' (Expert 4)	Dilemma driven by differences in behaviour driven by the need to be professional and innovate or driven by profits as needed by the firm who is operating in the particular business model, motivation is connected to organisational culture
EI 2	**Heavy liability contracts, lack of rewards – sharing liability and reward**	Liability in contracts causes people to stay within their comfort zone to ensure their firm does not lose, this comfort zone is defined by the fragmentation of the market. Lack of rewards do not incentivise team to step out of comfort zone as needed by innovative actions	Khosrowshahi & Arayici, 2012; Barrett, 2018;	'Sometimes an individual will be under pressure by the organisation to make more or increase the profit margin or to get paper work from the client that can be motivating and if we get different motivations we get clashes from the motivations that can be problematic I think the disciplinary thing is really complex in the professional cultures' (Expert 4) 'I think that's a habitual thing on the constructing side of business and some contractors have come to a point where they think that's the only way they can make money, yeah they wake up with 1 or 2 or 3% of the money so they underbid the work in the first place and then wherever possible blame the architect or engineer for changes so they can pull money back from the contract which is very decisive' (Expert 5)	Evident in the way motivations of various teams clash or increasing their own firm's profits; enabled by the contracts, individualistic rewards which vary; therefore motivation varies

	Empirical Critical Factors	Possible Reasoning	Key Literature Associated	Expert (Dis)Confirmation (if any)	Missing or Elaborated Aspects
EI 3	**The service mentality – the need for investment mentality**	The 'I do my part and you do yours' mentality driven by individual contracts treating teams like a service keeps them from investing into the long-term goals of the project. Norwegian contractor both explained that there are higher profits in investing into assets by themselves, in turn, allowing more control of digitally driven innovation	Bresnen & Marshall, 2000; Barrett, 2018; Dulaimi *et al.*, 2002;	'It's a service <but> It should be investment, but clients aren't open to it they don't believe it, they think I'm selling this car or something that got no wheel but it's an investment' (Expert 4) 'there's also arguments about whose fault it is that the client has paid more money for things, which means, you know sometimes they don't communicate at all' (Expert 5)	Link made between service interpretation of contracts to the project level and client mentality
EI 4	**Industry fragmentation**	Traditional treatment of fragmentation means more individual contracts. More individual contracts would bring more individualistic goals and more probability of win-lose mentality	Barrett & Sexton, 2006	'…the procurement models are always quite limited in when we engage with the supply chain because we have a 6-year framework, we can bring them in early to grasp the line of work, to gain efficiency, we've never been able to do that... actually when you are in a framework for 6 years what's really important is that you have really strong relationships... Contractual procurement drives behaviour around sub-contracting and if you can have example an early contractual involvement phase of a job and you are allowed to bring a supply chain and expert to inform what you are doing, you can really make informed	Framework (long-term) contracts have been introduced by some major public clients to incentivise early involvement of specialists when needed, long-term frameworks also incentivise better understanding of other partner firms.

	Empirical Critical Factors	Possible Reasoning	Key Literature Associated	Expert (Dis)Confirmation (if any)	Missing or Elaborated Aspects
				decisions and make really big efficiency savings as well' (Expert 1)	
EI 5	**Differentiating innovation in project lifecycle**	Siloed nature of education, differences in profession-based culture, software capability, etc.	Blayse & Manley, 2004	Did not emerge	
EI 6	**Contractual nature of addressing collaboration**	Collaboration is not valued by all, the culture is to work in silos which is perceived as normal, inhibits impact of digitalisation. Transformation of contractual needs to lower level successful collaboration is lacking	Asad *et al.*, 2005; Buvik & Rolfsen, 2015	'if collaboration isn't built into those contracts, it's very hard to get them to do it...if it's not rightly built in procedurally to the processes that they have to adhere to, or if they don't adhere to the objectives that they need to get paid' (Expert 3)	The mechanisms to get people to collaborate by the use of i.e. project wide workshops and activities, need to be built into the contract. However, the belief in the use of the workshops need to be ensured
EI 7	**Non-relationship focus of team selection**	Human factors are non-tangible, lack of awareness of significance, people are technically educated	Blayse and Manley, 2004;Kumaraswamy and Dulaimi, 2001;Buvik & Rolfsen, 2015	'Actually we have days that people would see the person that they want to work with, I think there's another side of this where you put in a tender for a project, as a consultant, the next stage is you get interviewed by the client, then it's like rather impulsive because the client doesn't work with you surely you should be interviewed by other members other team or they should be other tenderers and have some, you should facilitate it in such a way that you involve other people and have something worked out so that you can have cohesive teams' (Expert 4)	Social psychology-based methods can be adopted to enhance the team selection procedure; by finding the right blend of people to work together but not necessarily changing the firm contracted.

	Empirical Critical Factors	Possible Reasoning	Key Literature Associated	Expert (Dis)Confirmation (if any)	Missing or Elaborated Aspects
EI 8	**Discrepancy of tender information and reality**	Business ethics inadequately addressed by the industry, lack of verification of information at tender stage	Vee & Skitmore, 2003	'… I walk into the reception and there are TV screens all over that show live data about what's going on, that's never existed and yes you scratch beneath the surface, if this data is any good but I don't believe that the people in the boardroom have been able to, in my perception hide behind the fact that there has never been that public face invisibility about what's been going on. Within that boardroom probably, everybody knew what was going on…its business ethics that's what's caused a lot of issues' (Expert 1)	Business ethics forms an underlying theme when issues surrounding inter-organisational and intra-organisational practices; its emergence is most suitable in Human Psychology and Culture level signifying resulting to symptoms as a result of procurement strategies. Lack of transparency in large firms has been a cultural norm, however, driven by failure (Carillion) some firms are working towards connecting information flow between multiple layers of the organisational hierarchy. It can be assumed that the procurement part of large contracting firms is not in consistent contact with staff who will carry out the project.
EI 9	**Non-personality/team chemistry based selection**	Natural characteristics are important, trust cannot be created even if incentivised in some	Buvik & Rolfsen, 2015; (Kumaraswamy and Dulaimi, 2001)	'…you can actually do a one day event that could sort that out some exercise and you can call it project scalping event where you get initial ideas, initial thoughts people want to be on their best	There is need to apply social psychology-based methodology to assess

	Empirical Critical Factors	Possible Reasoning	Key Literature Associated	Expert (Dis)Confirmation (if any)	Missing or Elaborated Aspects
		cases. Lack of awareness of human factor and application of social science and psychology methods to understand chemistry between teams.		behaviour but they seem cracked after a couple of hours so you'll start to see the kind of things coming through so you'd be able to know who would make a good team so you can balance what comes with that with the actual denominate of the tender stuff. (Expert 4)	team chemistry as part of the tender phase

7.5.2 Validation of Meso Level 1 from Literature

The empirical evidence summarised in Table 23 is explained and justified with evidence from existing knowledge in this section, forming the foundation to understanding the impact of meso level 1 on decision-making.

In light of the empirical claim that the business model and digitalisation instil clashing project level behaviour, the 'profit vs professionalism' dilemma was found in design team participants by interpretive research (Barrett, 2018, p. 364); conflicting intrinsic motivation of delivering innovative outcomes to contribute to industry improvement with the extrinsic need to provide profits for the employer. Expert 4 confirmed the 'dual personalities' as a result of the tension in relationships between innovation and profit; innovation requires investment (EI3). However, the norm is for firms to operate polarised services going against the inter-disciplinary dependent solutions needed in AEC projects (Dulaimi et al., 2002). Therefore, the current practice driven by cultural norms brings about a service mentality (collaborating by splitting work) rather than an investment mentality (dynamic collaboration with openness and trust) as needed by increased innovative activities to drive implementation of digitalisation, this is further discussed in Section 8.3.2. To go beyond operating like a service, it is widely acknowledged that there is need to form partnerships and alliances to enhance cooperative problem solving by creating a shared project vision (Blayse and Manley, 2004); enhancing trust and openness. Project level innovation is inherently linked to the procurement system (Walker and Hampson, 2008) and is therefore linked with the way a firm generates profit; therefore, needing alignment between the motivations to generate profit and innovation (EI1); Kumaraswamy and Dulaimi (2001) explains the misalignment to motivations as a major cause in restricting innovative inter-team effectiveness.

Liability has also been found to be a barrier towards the implementation of BIM (Khosrowshahi and Arayici, 2012); when there is a higher possibility to be held liable, practitioners tend to stay within their comfort zone (EI2). The risk of innovative activities to individual firms is reduced by partnering arrangements' effect on better integrated and collaborative environments (Bresnen and Marshall, 2000a). The need for professionalism to engage in innovative actions is intrinsically motivated (Barrett, 2018), however, to allow for effective implementation of digitalisation, extrinsic motivation is required to ensure employers of individuals are certain of gains in profit driven by innovation (EI3). Furthermore, contractors in Study 2 explained the higher profits driven by increased freedom in developing innovative practice in their own building investments (dealing with the client directly), suggesting that integrated environments facilitate better innovative practice.

If the interaction environment (between teams) is aggressive, this pushes firms into reactive behaviour (Bresnen and Marshall, 2000a) suggesting that liability reinforces reactive behaviour (EI2). On the other hand, the fragmented nature of the industry where contracts are

individualistic coupled with the transient nature requiring development of new relationships are not helping in reducing the aggression in the interaction environment (EI4). The transient nature of the industry limits the positive impact brought by prior ties and potential trust development (Buvik and Rolfsen, 2015). Blayse and Manley (2004) suggests that there is need to move to integrated approaches going against the one-off nature of the industry. Additionally, Expert 1 explains the use of long-term frameworks having a positive effect on relationships and interaction environments. The study of best practices found that client and procurement route plays a vital role in promoting innovation and collaboration within construction (Asad et al., 2005). As part of this research, the addressing of innovation incentives (and therefore collaborative practice) as part of the contract was found to be vital (EI6). The contractual arrangements were linked to the ability of teams to trust one another at the project level (Kadefors, 2004).

The non-relationship focus of team selection (EI7 and EI9) is supported by the better innovation capability of design teams who are appointed using contemporary, integrated methods as compared to traditional methods (Forgues and Koskela, 2009). The organisations or groups to be appointed need to have established beliefs aligned with other teams in the way that they deliver the desired outcome (Kumaraswamy and Dulaimi, 2001). Expert 4 suggested using social psychology methods to determine the ideal inter-team relationships according to the needs of the project.

In the current methods of team selection, discrepancy was found in information provided by firms at tender and after award (EI8). Expert 1 explains the link with business ethics where there is a lack of transparency in the firm tendering for a job; the team tendering is different to the team that will operate, there is a lack of intra-organisational collaboration in large contracting firms. Collusive tendering is acknowledged as a common practice (Vee and Skitmore, 2003).

7.5.3 Validation of Meso Level 2 from Experts

Table 24 shows meso level 2 factors established from Studies 1 and 2, open questions based on these issues were made to seek expert confirmation/disagreement and/or elaboration. EC7 and EC10 did not emerge in the expert interviews.

Table 24: Meso Level 2 Empirical Factor (dis)confirmation or Elaboration

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
EC1	**Client technical knowledge**	Not incentivised and lack of awareness of importance in client firms	Hedgren & Stehn, 2014; Engström & Hedgren, 2012; Neill & Rose, 2007; Rachel Dinur, 2011; Levander *et al.*, 2011; Daft & Weick, 1984;	'this was the first major construction project that they had done so they didn't have the in-house capability to understand what the construction company or design house needed. They also didn't have within the organisation any I guess, role or process that enabled it to happen so structurally they were I guess blowing in the wind. There was nothing set up that they could go - right, this is how we are going to collaborate and communicate and assure ourselves that they are doing what we want them to be doing' (Expert 3)	Relates to the client's organisation setup, their experience as being a client, leading to the way the project is set up technically
EC2	**Client perception of industry culture**	Long-term traditional values running culturally in client firms; internal policies of client firms which are set to make the Client Representative think about cost control in a fixed manner resulting in lack of client trust	Boukendour, 2007; Van Duren & Voordijk, 2015	'it's about finding what the cause is when clients don't trust you and dealing with that. Again, we don't have such conversations early enough… could be stereotypically driven...I'm assuming these are construction clients you know so if there's a client who's a public sector they've read something about an architecture embezzling or the funds you will notice with the contractors that were going along' (Expert 2)	Client trust is as a result of stereotypical views as a result of e.g., media coverage, the procurement culture in the industry is not allowing for early dialogue between key stakeholders and the client to develop the trust against the typical perception
EC3	**Hierarchy of client organisational culture**	The Client Representative is contracted to the client organisation in a way	Schneeweiβ, 1995; Kometa, Olomolaiye & Harris, 1996; Barnard & Simon, 1947	'private clients are more decisive, without hesitation… It's culture is different in a way of accountability, their working culture is different I know I'm	Accountability within the client's organisational structure or hierarchy

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
		that inflicts personal liability, Client Representative is in a position where faults can be traced back and made public		generalizing massively but I've worked in both the private and public sector line of employment and I know in a private sector you have to justify everything that you spend… it has been all checked and accounted for so I have to work. But in the public sector like the university I want to take time to talk to somebody and I don't know what the output will be it doesn't matter therefore I can be decisive about my time and the decisions that I make because if your time is not accounted for then you can be slower about the decisions that you make and you have to make the decision that day because you'll be working on something else tomorrow' (Expert 4)	affects the representative's ability to make decisions
EC4	**Client involvement in contract development**	If the contracts are direct to the client, there is risk of the client not having sufficient knowledge to make decisions. Financial leverage to the project management firm allows for control over the other teams	Che Ibrahim, Costello & Wilkinson, 2015	'the client can contract separately to the construction house or the design house or they can have one contract with a group of companies that have arranged themselves so it's either one contract or two contracts. So in the case of the project we were on...was two separate contracts so there was actually no contractual relationship between the designers and the construction company so when they tried to ask each other to do something there was no I guess commercial reason for them to do it they	The client's decision to select contracts is either restricting or allowing collaboration between teams in different parts of the project lifecycle

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
				were like - you are not my client' (Expert 3)	
EC5	**Client perception of own role**	Client's involvement is vital to the team's motivation and their own understanding of processes that teams utilise to interoperate	Loosemore & Richard, 2015; Thompson, 1991; Egan, 2002; Rajakallio *et al.*, 2017	'very clear questions the clients would ask, you know demonstrate the method statement, how you will collaborate and share model environment and share information and data. So, unless the client is buying it you would think the client is not really interested. Remember most of the collaboration that goes on, I mean a client generally collaborates T1 normally, from T2, T3, T4 to designers who will collaborate with those parties but not the client. The client has generally got 2 or 3 points of contracts with who they are inter-phasing with and collaborating with' (Expert 2)	Client involvement is not needed in all the phases, however, there are lifecycle phases that require high involvement
EC6	**Client knowledge of own needs**	The client needs affect the client requirements that teams are developing a product for, therefore, if the requirements consistently change, this brings inefficiency	Loosemore & Richard, 2015; Kometa, Olomolaiye & Harris, 1996	'<framework (long-term)>contracts actually the on-boarding and training process for <public client> hasn't really been as strong as ours, so they need to upskill themselves in terms of what's the contract, what's the arrangement, what's the job, what's the state of the relationship, where are the pressure points, what's the risk, they haven't had that, we know more than them at the moment' (Expert 1)	Client knowledge of own needs depends on the contractual agreement with teams, some contracts delegate some decision-making responsibility regarding the needs of the client

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
EC7	**Clients influence on team selection**	Team selection is critical in ensuring that teams can interoperate efficiently with the skills, personality and experience they have	Che Ibrahim, Costello & Wilkinson, 2015; De Araújo, Alencar & de Miranda Mota, 2017; Briscoe *et al.*, 2004; Kometa, Olomolaiye & Harris, 1996; Loosemore & Richard, 2015	Did not emerge	
EC8	**Client financial stability and flexibility**	The lack of financial flexibility can bring about less motivation to teams when the client requirements change as they question whether they can be paid as agreed. Extra works claims can be rejected	Kometa, Olomolaiye & Harris, 1996	'I think the biggest issue I guess in the highways construction is probably the money, there's just no money...but there is always so much change within highways projects because as soon as you dig a hole in the ground, you are going to find something because you have dug there before and it's going to have an impact on the works. It's going to cost time or money and someone has got to pay for that and the construction companies don't want to pay because the margins are already so thin and <public client > doesn't want to pay because it is tax payers money so then it gets extremely difficult because of the commercial arrangements and the lawyers get involved and financial accountants get involved and it all comes down to determining who's cost that changes and the relationship can get quite obscure and so that's one particular decision-making	Client driven project financial management is tested when changes that cost come into place. The financial origins of the client inherit factors (e.g., accountability) that affect the way that the client responds to additional cost.

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
				process I guess that takes a really long time, we can, you know, sometimes it can take 3 months, sometimes it can take 2, 4, 5 years a lot of times projects are done by the time they can even determine if they have made profit on the project..' (Expert 3)	
EC9	**Client attitude**	The client's attitude makes the consultants fear to be open about innovative solutions	Kometa, Olomolaiye & Harris, 1996	'I've had one clients who's just on the phone at least five times a day have you sent an email have you done that and I'm like if you stop micro managing you won't have time to deal with this stuff but then I have clients who go in this project and they are in my palms for six months and I'm like this is not useful at all' (Expert 4)	The attitude of the client is a symptom of multiple factors, the client trust towards teams, client organisational culture, client knowledge of the industry etc.
EC10	**Client perception of early investment on processes**	Processes like scripting of repetitive tasks can be done to reduce the time taken and human resources allocated	Hedgren & Stehn, 2014; Simon, 1965; Collins, Parrish & Gibson Jr, 2017; Luo *et al.*, 2016; Chang & Chiu, 2005; Loosemore & Richard, 2015; Briscoe *et al.*, 2004; Pesämaa, Larsson & Erik Eriksson, 2018	Did not emerge	
EC11	**Client's criteria for success**	Client demands are treated seriously by teams employed and therefore would make	Karen & Le, 2015; Babaeian Jelodar, Yiu & Wilkinson, 2016; Pesämaa, Larsson & Erik Eriksson, 2018; Kometa,	'do you feel that <trust and relationships> valued enough in the industry? Yeah...only with certain clients...A lot of clients we work with though they procure a building or a place	The way that the client values collaboration is connected to their knowledge about the industry

	Empirical Critical Factor	Possible Reasoning	Key Literature Associated	Expert Confirmation (if any)	Missing or Elaborated aspects
		collaboration important	Olomolaiye & Harris, 1996; Loosemore & Richard, 2015; Briscoe *et al.*, 2004	you in the lifecycle not every client will procure and often we find you know these one off clients do not want lots of collaboration you know they don't know enough. Governments who are constantly buying and procuring what marks better collaboration is the issue of knowledge between different projects and project skims and have systematic learning from collaborative work force.' (Expert 2)	

7.5.4 Validation of Meso Level 2 from Literature

The empirical evidence summarised in Table 24 is justified with existing literature forming the foundation to understanding client involved decision-making. Human relationships are said to be critical where trust and respect are found to be the determining factors (Briscoe et al., 2004; Che Ibrahim et al., 2015). This explains the deduction from empirical data, which shows that client involvement in selecting teams is critical (EC7); participants explain the need for transparency and trusting the lead management to procure teams. Participants present examples of projects where the client did not consult the leader before procurement, which hampered collaboration because of lacking trust and team cohesion. Participants claim that the client does not have the experience and knowledge to select teams on their own. On the other hand, project management firms tend to know from experience which firms can collaborate more efficiently.

The technical knowledge of the client (EC1) was said to be lacking by a number of participants, explaining that they do not have the skills to facilitate efficient technical dialogue. Engström & Hedgren (2012) found that heuristics developed from conventional buildings was being utilised to bridge the gap of the lack of technical knowledge brought about by prefabricated buildings. Hedgren & Stehn (2014) relate equivocality to decision-making. Equivocality is defined as the human problem of managing multiple meanings and conflicting interpretations (Weick, 1979). Numerous studies (e.g., Rachel Dinur (2011); Neill & Rose (2007); Levander *et al.* (2011)) associate equivocality with decision situations and innovation. In this context, decision makers (clients) may not know what information to search for or may not know how to interpret information. Interpretation of information dimension of equivocality results in testing the knowledge of a client, i.e. whether the client representative can use BIMM and comprehend the various parts of the model. Furthermore, the presence of equivocality shows that information can be perceived as unanalysable and therefore heuristics is utilised to consider soft information (heuristics) which is used to construct an interpretation (Daft and Weick, 1984).

The client's perception of the industry culture was related to the claim that the decision maker's heuristics make subjective judgement with respect to the status quo practice (Hedgren and Stehn, 2014); e.g., a number of participants explain the influence of the client's perception that firms are driven solely by financial goals.

The importance of basic psychological processes defining judgement and choice is highlighted by the decision theory by Einhorn & Hogarth (1981). These processes were split into four categories: information acquisition, information evaluation, action/choice and feedback/learning. These processes can be perceived as an iterative loop where value is gained from learning and applied to the following tasks. Applying this to organisational culture in relation to the claim that 'organisational hierarchy is killing collaboration' (EC3) can be seen that there is a lack of feedback/learning from project to project in the ways that the client firm changes. For example, some public client representatives were claimed to push relatively easy decisions up the

hierarchy, showing the highly perceived personal risk to making decisions. This was perceived as very inefficient by many participants resulting in a loss of motivation and continuity in team performance. Simon (1965) explains how a decentralised decision-making process in firms brings about relying more on the heuristics of the individual which can alleviate the propensity to prefer a reduced risk to a potential gain (Kahneman and Tversky, 1979). As suggested by the empirical evidence, if there is personal liability formally or informally, this can impact on decision-making negatively. Further empirical evidence suggests that the client's perception on early investment on processes (EC10) is critical, as the innovation that requires early investments is perceived as risky. Kahneman & Tversky (1979) claim of preference to reduced risk rather than potential gain affects the client's decision, empirical evidence suggests that if the client trusts the lead management firm, this reduces the preferential perception. Furthermore, Briscoe *et al.*, (2004) also explain that change needs to be driven by the client to make processes more efficient. However, empirical data shows that many clients lack the exposure and knowledge to manage innovation and therefore depend on the relationship with the leadership and teams.

Kometa, Olomolaiye & Harris (1996) studied the client generated risks to project consultants and presented client attributes that affect the performance of the consultant teams. The characteristics regarding the organisational structure and communication channels of the client are acknowledged to be important (EC3). The client's skill in organising the project team was related to their influence on how teams are selected (EC7), how teams were allocated with responsibility and coordination. The way the client manages the teams was described as their attitude (EC9) towards teams; participants claimed that a consulting client attitude rather than an enforcing attitude would result in better collaboration and cooperation. Additionally, Kometa, Olomolaiye & Harris (1996) attributed the client's project priorities which is related to the clients criteria for success (EC11).

Kometa, Olomolaiye & Harris (1996) and Zolghadri *et al.* (2011) explain the impact of the client's financial health on the project (EC8) and explains that the choice of the supply chain has a direct impact on the client financial health.

Rajakallio *et al.* (2017) explain that construction clients are recommended to follow a perceived standard industry logic known as normative beliefs in psychology. Pesämaa, Larsson & Erik Eriksson, (2018) expand, implying that known sets of solutions and processes are routinely applied on construction projects, presenting a critical factor; the client's perception of their own role (EC5) which depends on their normative beliefs.

Karen & Le (2015) explain the need for requiring efficient collaborations as one of the criteria for success (EC11), as there is loss in cost and time from differences in understanding of outcomes (Senescu et al., 2012). Additionally, Babaeian Jelodar, Yiu & Wilkinson (2016) explain that the priorities of firms and clients differ at the project level meaning that the criteria for success (EC11) is not well defined and supported contractually.

Projects are found to lack success when poorly coordinated (Pesämaa et al., 2018) making early investment on processes critical (EC10). Furthermore, Chang & Chiu (2005) suggest that poor process performance in projects could be due to the lack of its joint understanding showing the need to collaborate and exchange knowledge about the process.

Briscoe *et al.* (2004) studied the extent to which the client can increase the integration of the construction supply chain and finds that although the client is influenced by environmental variables, the client's role in selecting teams (EC7) and the desire of the client to develop relationships (EC11) is critically important.

Che Ibrahim, Costello & Wilkinson (2015) agree with the empirical claim that the client to some extent has control over which contractual agreement to use on the project (EC4).

Thompson (1991) explains that the role of the client (EC5) at the project level is crucial where there is need to intervene at development and implementation stages of the design and construction process.

Loosemore & Richard (2015) conducted a review of literature and found three attributes to a successful client; clarity of needs (EC6), active involvement in the project (EC5, EC11) and understanding that the lowest bid is not necessarily the best option (EC7). Additionally, Loosemore & Richard (2015) explains that there is need to have an innovation strategy involving the client, which would streamline processes and requires early investment (EC10).

Egan (2002b) presents a report that explains the need for clients to be encouraged to be involved more at the project level questioning their current role in projects (EC5).

Van Duren & Voordijk (2015) found that opportunism (self-interest) was common in the AEC industry but seems to be on the decline. Combining the existence of opportunism and the previously mentioned heuristics and normative beliefs that are developed from past experiences, empirical evidence suggests that some clients base decisions on the belief that opportunism is still common and a viable risk (EC2). Boukendour (2007) explains the negative effect of opportunism on collaboration and cooperation. Empirical evidence allows expansion based on this claim; the presence of opportunism in past experience of a client can bring assumptions that making innovative activities are risky (EC10) alleviated due to the lack of technical knowledge (EC1). Therefore, it is possible that an opportunity to improve is neglected and decision is made to reduce the risk (Kahneman and Tversky, 1979) as a result of this normative belief.

7.6 Discussion of Validation Impact on Original Model

The expert views and literature both confirm the structure of the model as in the external analysis model (micro, meso and macro). A further additional level was added due to aspects emerging in multiple levels called Human Psychology and Culture (HP&C), other social scientific research (see Barrett, 2018) also shows the rooted nature of themes; the strength of relationships between

practitioners were as a result of stereotyping and decisions made influenced by relationships. The implications of this claim are discussed in Chapter 8.

Multiple gaps were found directly held in the HP&C level; 6 out of 11 gaps including, business ethics, stereotypes, continuous learning, personality variance, social well-being and tribalism. Studies 1 and 2 practitioners' linguistic capability to express human factor based themes were limited due to the highly technical nature of project level participants. The experts differed, they were strategists or practitioners with a background in psychology which enabled improved lingual capability to express more hidden rooted factors.

Another significant gap was in the position of trust also occurring in both meso and macro and therefore should be held in the HP&C level; the data collected from individuals at the project level gave the impression that trust between individuals was solely micro, experts expressed the need for people to trust the management systems, the way the contract is used/made and the capability of other teams.

Other gaps included the organisation's role in empowerment, processes of delegating trust and responsibility, vertical collaboration in relation to business ethics.

Although all parts contribute to the resultant collaborative behaviour, as in Section 6.2.1, the meso level was chosen to focus on theoretical application. Therefore, the meso level was critically validated both with expert views and literature. This was to ensure that the empirical accounts reflected reality in order to use them as the basis of theoretical application as discussed in Section 8.3.1.

The emergent empirical claim that there is a service-based mentality in the industry was supported by literature and experts. However, the nature of digital changes needed at the systemic level was suggested to require investment mentalities; this was externally validated by the 'profit vs professionalism' dilemma (Barrett, 2018). In Section 8.3.2 the effect of a more investment-based mentality on the biases in decision-making driven by meso factors are discussed.

7.7 Summary

Validating interpretive research differs from the positivist (commonly used in CM domain) as quantitative validation of more subjective data is unsuitable. To address this paradigmatic limitation, expert interviews were held, and literature was used to confirm or disconfirm empirical findings. Furthermore, Studies 1 and 2 research design utilised participatory collaboration to understand the causes of challenges in project level collaboration. The structure of the model was supported by expert views where improvements in visualisation of individual levels suggested; the adapted versions taking this into account are shown in Figure 53.

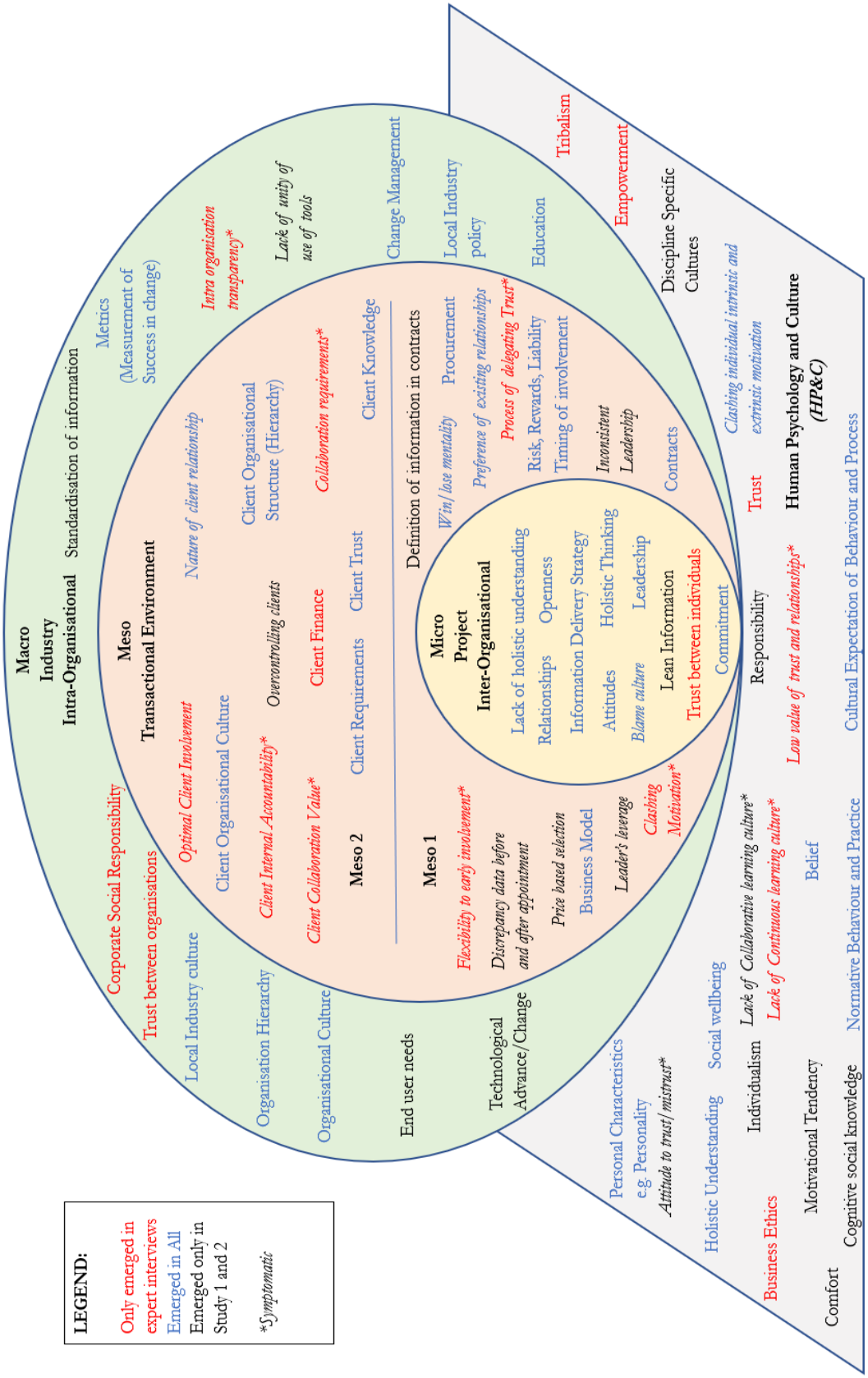


Figure 53: Updated Factors in Holistic Model for Collaboration in the AEC Industry (HMC-AEC)

8. DISCUSSION

8.1 Evolution of the Research

The initial aim of the research involved developing a numerical tool to 'measure' project level collaboration in real-time by using social science based quantitative methods (***SRQ1 - Can project level collaboration be measured?****);* as a result of the need for metrics to measure project and innovation success (Succar et al., 2012; Nasir et al., 2012). The exploratory study used a mixed methods-based approach to compare design teams' collaboration on two projects in Zambia. However, due to the low statistical validity of the quantitative data caused by the limited number of participants who engaged in interdisciplinary collaboration and the limited validity of constructs used to develop a numerical tool, the methods of the research required revisiting. Although there are some similarities between the exploratory study's qualitative and quantitative data, the complexity of project level collaboration was evident in the qualitative data collected and therefore concluded that the quantitative tool was not precise enough because of the statistical limitations. One aspect that came across as surprising was the more collaborative Project B had a more fragmented project team; emphasising reiterating the potential of human factors in increasing inter-team efficiency despite formal barriers.

Driven by the exploratory study's outcome, the research's philosophical paradigm was changed from positivist to critical realist to understand the reality in project level collaboration (***SRQ2 - What methodological paradigms are suitable to understand the reality of project level collaboration?***).

To fulfil RQ2, studies were conducted in Finland and Norway by collecting qualitative data using a semi-structured approach regarding collaboration, and only using topics from the exploratory study as probes. The use of collaboration as a key point of departure links both the business and project perspectives as the value in both sides are added by improving project success which requires teams to collaborate to create value. This enables a holistic perspective as required in the Construction Management (CM) research domain (Phua, 2013). Furthermore, using multiple geographical locations and various approaches in collecting data allowed the possibility of result convergence by changing the perspectives; a form of internal validation. Therefore, generalisability was achieved, not in the application of the factors, but in the existence of the factors originating from data collected in Finnish, Norwegian and UK AEC industry (***SRQ3 - What factors affect project level collaboration according to project level practitioners?***) The factors were also compared to literature. Holistic models by Moum, Luras and Barrett (see Section 2.2.3) of designer collaboration provided a basis for understanding the way the factors interact. Moum used a similar structure with micro, meso and macro. Barrett identified some factors and explained that these factors are applied depending on ingroup and outgroup. Whereas, Luras described the way decisions are made in the design situation which

affect the design, social system and sensemaking process of the practitioner. These interpretations were used implicitly with experiences from practitioners to develop a general model (***SRQ4 - How can the factors that affect collaborative environments be visually interpreted?***). The factors were generalised under categories defined by Van Notten's external analysis model of which some factors emerged as part of all categories resulting in a foundation level; Human Psychology and Culture (HP&C). Based on the impact, controllability and time taken to change, the meso level was selected for higher focus and theoretical application from psychology (***SRQ5 - Which factors are most practical to change and impactful in driving industry wide change to suit project level collaboration and implementing digitalisation?***). The factors found, a Holistic Model for Collaboration in the AEC industry (HMC-AEC) developed, selection of the meso level were all validated using expert views and existing literature (***SRQ6 - How do expert views from literature and practice compare to project level views?***).

The HMC-AEC includes a variety of factors, emergent from reality owing to the interpretive nature and semi-structured approach of data collection. However, the focus is in meso aspects and the holistic use of the HMC-AEC. In answering the overall research question, two approaches were taken:

1. Contextual understanding and reflection (RQ3): holistic comparison of human factor initiatives in the AEC industry and similar industries (defence and health care). The aim was to find initiatives in other industries which can be applied in the AEC industry to bridge the empirically evident lack of understanding and perceived importance of human factors. SRQ7 (***how are factors rooted in HP&C valued in the AEC industry compared to similar industries?***) is answered in Section 8.2.1. To answer SRQ8 (***how can AEC collaboration models be adapted to suit realistic nature of factors?***), in Section 8.2.2, the findings from the thesis and defence industry (Human Factors Integration) are compared to an existing AEC model (IDDS).
2. Theoretical understanding, reflection and integration (RQ4): Section 8.3 focuses theoretical application and reflection from holistic understanding on the meso level of the HMC-AEC. Figure 54 shows an overview of the conceptual interaction that the discussion in Part 2 of this chapter is framed within.

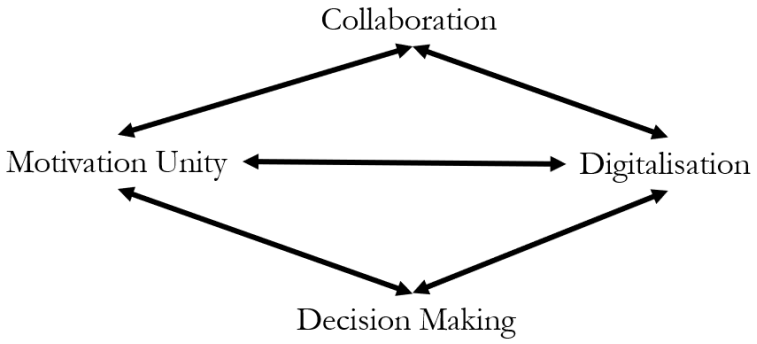


Figure 54: Summary of Interacting Concepts Discussed

a. Application of psychology decision-making theory in observed empirical factors/issues centred about the meso level (contracts, business model, procurement and client organisation) was done to exemplify the way that the rooted nature of HP&C impacts the application of meso level factors. SRQ9 (***how are the psychological and social aspects affecting project level decision-making and collaboration at the meso level?***) is answered in Section 8.3.1. The root causes are established beliefs represented in empirical evidence and connected to various biases in decision-making.

b. SRQ10 (***how is the meso level affecting the mentality of collaboration implementation of digitalisation at the project level?***) is answered in Section 8.3.2. Various concepts that contribute to motivation of practitioners are combined in a schematic in Section 8.3.2.1. The ideal practice is compared to traditional practice in relation to digitalisation in Section 8.3.2.2; the need for an investment mentality as opposed to a service mentality is discussed to suit digital transformation. The subjective nature of contracts is linked to artefacts in the HP&C level in relation to intrinsic and extrinsic motivation of individuals and teams.

8.2 Part 1: Contextual and Objective view of Human Psychology and Culture in the AEC Industry in Comparison to Similar Industries

Human factors in the CM domain emerges predominantly in site health and safety application (Wong et al., 2019). In project performance or collaboration focussed literature, studies exist with aspects of the human factors, e.g.,, trust (Pishdad-Bozorgi and Beliveau, 2016), and relationships (Ibrahim et al., 2011). The dominant focus is arguably not holistic (Phua, 2013) but of fragmented aspects of human factors. The HMC-AEC developed in this thesis shows the rooted nature of collaboration as HP&C aspects. Therefore, making human factors is critical to all levels of the model. It is acknowledged here that human factors have a wider definition than HP&C. In the scope of this project, it can be assumed to be representative of all aspects of the HMC-AEC, as defined in defence industry's framework (Ministry of Defence, 2015a) and explained by an expert with a background in human factors. AEC literature is certainly lacking maturity in defining the constituents of the human factors; e.g., it is treated reductively with the same importance as process and tools in the IDDS model.

The AEC industry is a project based industry similar in nature to defence and health care (J. Taylor, 2005). Therefore, the consideration of human factors in the industrial and institutional levels in these industries can be drawn from to bring value to the AEC industry. The following sections seek to understand initiatives taken in these two industries, to attain an objective view of applicability of findings (SRQ7 and SRQ8):

1. Health care: biopsychosocial approach is used to educate practitioners of effective collaboration,
2. Defence: Human Factors Integration (HFI) regulations released by UK government outlines strategy to facilitate common language and process oriented around human capability.

A commonality between these industries and the AEC is in the nature of work (J. Taylor, 2005), brought about by multiple business ecosystems overlapping, influencing and creating exchanges across professional boundaries. To encourage holistic thinking, the health care industry introduced the biopsychosocial model and the defence industry introduced regulation of human factors both of which to improve inter-disciplinary solutions by increasing unity of risk perception and consideration. In this section, this comparison enables an objective view of how the AEC industry is dealing with the HP&C aspects of collaboration and digitalisation.

8.2.1 The Biopsychosocial Approach in Health Care

The biopsychosocial approach was introduced in 1977 to show the reductionist's over-simplification effect in the existing biomedical model where physical origins are assumed to be causes of diseases. A patient's illness has been defined by western medicine in a reductionist approach from the 16th and 17th centuries with the idea that mind and body are separate phenomena, still a majority view in today's health care practice delegated by the biomedical model

(Wade and Halligan, 2017). As Engel (1977) explained with the biopsychosocial approach, there is a need to consider both the social/psychological and physical dimensions of illness and the patient. Although this simplification did have considerable success in the diagnosis and treatment of life-threatening diseases, however, well recognized illnesses with no physical origin are not accounted for e.g., 'neurasthenia'. Other scholars also accounted for this difficulty (Kleinman et al., 1978); in simplifying the way knowledge is created, all possibilities of intervention or innovation are not captured.

Similarly in the AEC industry, the social scientific research presented both in this thesis and in other literature, explains the need to consider the social and psychological dimensions in solution delivery (Barrett, 2018). From health care, it is evident that the historically driven reductionist approach forms the norm in education and research and therefore in daily practice. However, interventions to encourage holistic thinking are in health care education based on the biopsychosocial approach. In the AEC industry and this research, education emerged in both Studies 1 and 2, and all experts explain the siloed nature of discipline specific education having an impact in inter-disciplinary solution delivery. The cause of this siloed nature is disputable; engineering courses are highly reductionist/positivist whereas architecture courses tend to be more interpretive according to experts. Furthermore, many educational institutions take on fragmented discipline specific education delivery. Therefore, knowledge transfer to practitioners from education is siloed; an expert explains that the intern training at their firm is predominantly in negotiation and people skills to bridge the gap of human factor understanding and skills.

Although multiple scholars have raised awareness and received credit in the health care sector about biopsychosocial model addressing missing parts of the biomedical model; a paradigm change has not occurred until today (Wade and Halligan, 2017). Similarly, in the AEC industry, firms are operating in a fragmented industry environment motivated to reduce their own risk. However, digitalisation is suited by higher integrated environments to reduce project risk bringing about a paradox in the industry both in behaviour of people and in business model innovation. The HMC-AEC presented in this research can be utilised to raise awareness of the value of HP&C aspects both in research and practice. One expert explained the impact of the model as a pedagogic tool, to get students and practitioners to understand the bigger picture of their operations. Furthermore, as an outcome, AEC education could take on case study reflection approaches such as in the health care industry, to allow students to venture outside the discipline specific boundaries; bringing awareness of otherwise hidden aspects.

Collaboration in health care requires the patient and the health care team to share a common understanding of the illness (i.e. to use the same mental model) or management of treatment may fail (Horowitz et al., 2004). Central to this exchange is trust (Zhixia and Mengchu, 2018). Similarly, in the AEC industry the client requires to have a similar thinking process to teams to holistically envisage their needs. This is better enabled by an open collaborative environment

as the teams can provide technical advice from their vast experience. However, as empirical evidence suggests, beliefs driven from experience and culture create a barrier between client and teams (explained further in Section 8.3.1) bringing about mistrust. To elevate the trust, motivations of client and teams require unification (as further explained in Section 8.3.2).

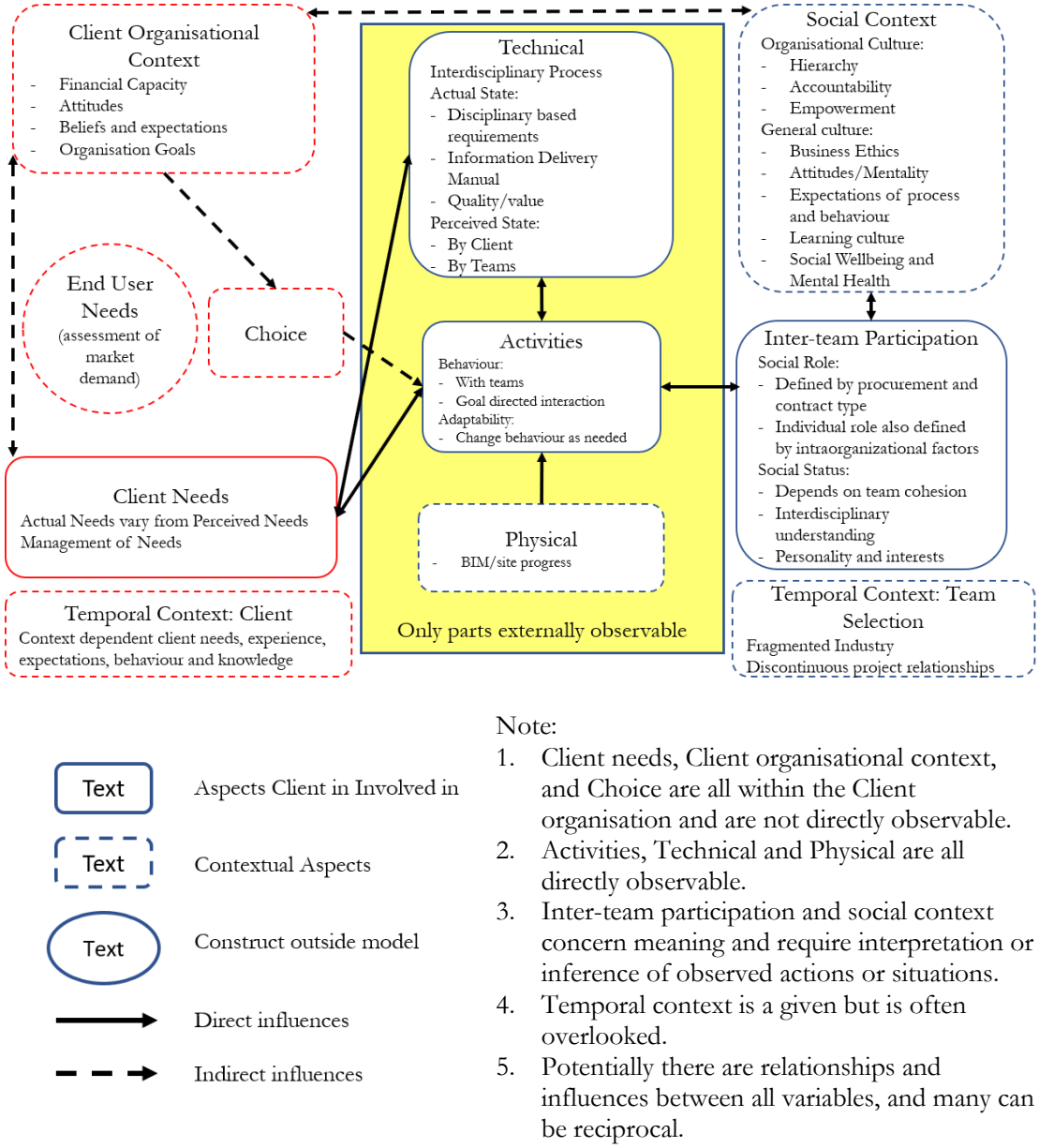


Figure 55: A Systems Model Reflection of the Biopsychosocial Model (Adapted from Wade and Halligan, 2017)

Figure 55 shows a framework structure used in health care that was adapted to the AEC industry due to the high similarity in phenomena; a systems model used to visualise biopsychosocial model is relevant. On the left (in red) are hidden aspects of the client. In the centre (in yellow) are the observable aspects, mainly technical and inter-team activity based. On the right is the psychological and social aspects that are also hidden. Just as suggested in the original model and interdependencies found in this research; relationships and influences between all variables exist and could be reciprocal. However as in systems theory (Vandenbroeck et al., 2014), the value for

an objective view is not in the individual variables brought about by reductionist approaches and mentalities from traditional science; reiterating the need for more holistically departing studies (Phua, 2013). The value is in the interacting systems, of which only a few aspects are observable; even when observable aspects are working well, projects can fail because of the other hidden factors. AEC based literature is highly technical (Hjelseth, 2017) and positivist in nature (Barrett, 2018), awareness of the hidden aspects are required for further understanding in practice and research. The systems framework (Figure 55) and the HMC-AEC (Figure 53) presents the links between these interacting systems.

The hidden nature of the factors brings a tangibility bias according to health care literature applied in physiology (Thiele et al., 2011). In the AEC domain, this bias is evident from the way people make decisions and judgements delegated by beliefs and expectations of normal practice indicating a low perceived value of the human factors; as it is not tangible, it is not perceived as important. One expert interviewed (i.e., human factors specialist) raised the difficulty in bringing people to understand the hidden factors, the normative attitude is to treat them like technical factors which have a definite beginning and end. The mentality is to treat them as a 'to do checklist' rather than give them foundational value. This needs to change to enhance positive collaboration and holistic education, models, such as the one developed in this research, can be used as a tool to drive and make this change.

Practitioners feel more comfortable dealing with factors they can numerically estimate representing the certainty effect (Kahneman and Tversky, 2013). Since it is not plausible to numerically estimate all the hidden human factors, practitioners tend to give the tangible technical aspects more importance. Deducing that it is human nature to seek certainty where tangible factors appear more certain.

8.2.2 Human Factors Integration (HFI) in the Defence Industry

The defence industry unlike the AEC industry, has regulated processes with respect to human factors. The need for the AEC to have regulation of human factors was expressed by experts, one expert explained the absurdity in 'a multimillion-pound project failing because of personality clashes'. An expert with experience in the defence industry explained there is need to consider human capability and mitigate risks from interactions between human capability and project processes. The regulation streamlines the processes practitioners take to consider human capability, in delegating roles, processes and use of tools; therefore, enabling greater unity in project risk perception.

The UK government released HFI regulation in the defence industry in 2015 which seeks to provide a lens to the industry from a human capability standpoint, not discerning the more technical policies, however, made to supplement them (Ministry of Defence, 2015a).

The regulation does not intend to give detail; however, it provides a holistic view of the process by clarification of solutions which otherwise would have multiple methods. This is so

that people can align their mental processes giving common ground for normative beliefs to develop, therefore, uniting human oriented risk perception. Many risks at the project level are not independent, they are systemic in nature; they have influence on multiple teams.

The abstract overview used by the HFI regulation is similar to the IDDS model (Figure 1) but adds a foundational level referred to as the 'environment' which is dependent on human capability. In the IDDS model, the human capability is captured within the 'collaborating people' part of the model. In the HMC-AEC, the HP&C part of capability (environment) is also found to affect all parts of the model and therefore requires foundational setting as in the HFI regulation. However, human capability as in the HFI regulation goes beyond HP&C, making the unique contribution of this thesis visually represented in the abstract model in Figure 56.

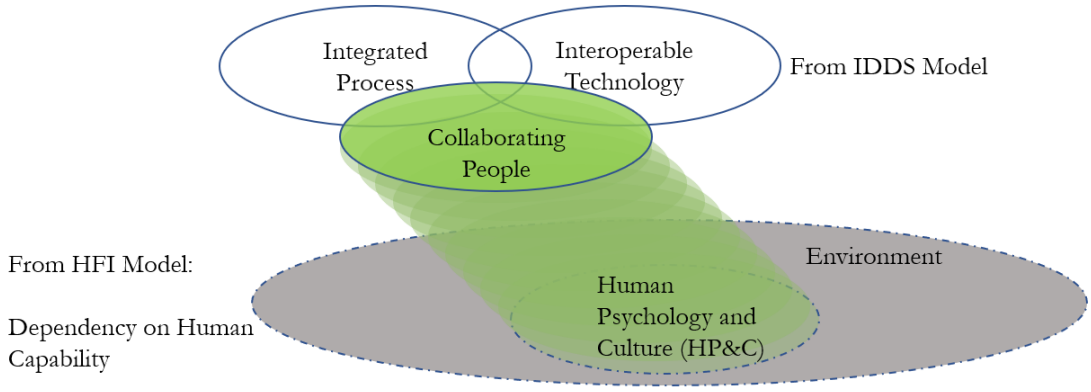


Figure 56: Contribution from Defence HFI to AEC IDDS Perspective (Adapted from Owen *et al.*, 2009; Ministry of Defence, 2015b)

8.2.3 Summary of Part 1

An objective view of the AEC industry's non-technical HP&C aspects was sought from similar industries. From the health care industry, an AEC systems model was developed shows numerous factors that are hidden in the way practice operates. This was enabled by the well-suited nature of findings with the systems approach used in the biopsychosocial model. From the comparison of the AEC and health care versions, the hidden nature of several factors is shown; the need for more non-reductionist or non-positivist research and knowledge transfer from practice. From reflection, the hidden client/end-user and social/psychological factors are critical to project success. Health care education utilises the biopsychosocial approach as preparing students to reflect on past cases to find the aspects that go beyond the contemporary biomedical model. Similar initiatives are needed in AEC education where most providers only scrape the surface of the world outside a disciplinary domain; the ability to think holistically requires a different approach to learning that involves reflection. Additionally, the comparison shows that trust is vital between the client and teams as they require to have a common understanding of requirements to develop solutions for. The common understanding between the client and teams in the AEC industry lack as teams are contracted for a phase of the lifecycle whereas clients

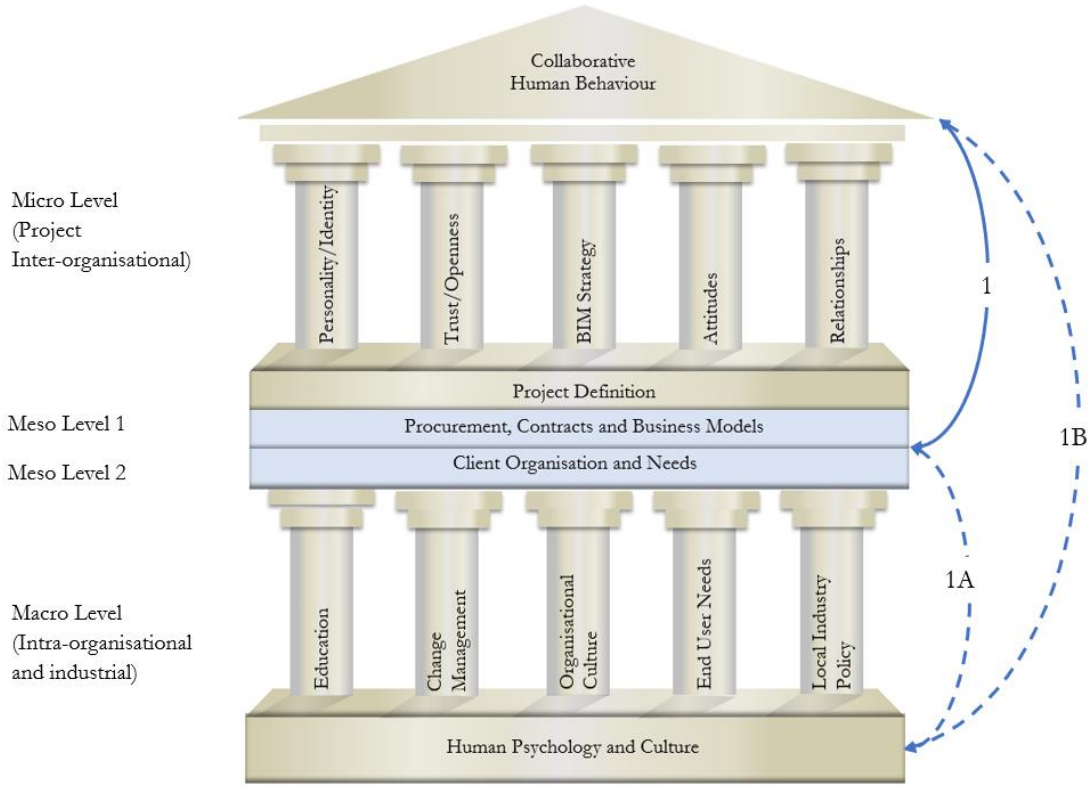
require to envisage the entire lifecycle, this is a reason for the suggested move towards an investment mentality in Section 8.3.2.

The defence industry's regulated approach to human factors is reflected on using the HFI model to answer SRQ8. The IDDS model used in the AEC industry appears unsuitably conveyed as environment and human capability of which, the HP&C level of the HMC-AEC forms a part. From the health care industry, there is an argument that the observable factors and the physical origin of disease are given more importance over the hidden aspects. The same can be said of the AEC industry; the hidden aspects of HP&C are not evident without reflective research, neither were they easily identified by practitioners. Therefore, it is needed to go beyond the conventional reductionist approach that focuses on the directly observable when studying complex topics that go across interdisciplinary boundaries.

To answer SRQ7, it is inevitable that studies in human factors have been more impactful in the health care and defence industries. Health care's initiatives to educate using holistic approaches and defence industry regulation are both transferrable long-term solutions for the increase in awareness and perceived value of these hidden aspects. Although as from the health care industry, implementing these changes and awareness will not itself bring a complete disruption, but it increases the ability of practitioners to think beyond their own disciplinary limitations which is needed by high performance collaborative teams. With reference to SRQ8, one of the main differences between the defence/health care and AEC industry is in the effect of failure; there is more direct risk to human life, therefore motivating curiosity of sector practitioners and researchers to investigate hidden human factors. In the AEC industry, the client takes up majority of the failure in terms of cost and time; direct risk to human life is only in a small part of the project lifecycle regarding site health and safety (studied by multiple scholars). This is partly the reason for the lack of perceived value in hidden factors in the industry as compared to the similar industries noted. Additionally, tangibility bias and certainty bias are connected to the lack of perceived value in human factors in health care (Thiele et al., 2011). This also applies to the AEC industry as people have a tendency to place more importance on certain and tangible aspects.

8.3 Part 2: Meso Level Theoretical Application and Implication

In Section 8.3.1, the influence of meso level factors on project level decision-making are discussed. Figure 57 shows the focus of this section; by using the empirical evidence that showed the influence of meso levels on collaborative behaviour (1), theories on bias decision-making from cognitive and motivational aspects were related (1A). In doing so, the model's hidden foundational level of the model's influence on collaborative human behaviour (1B) is exemplified. In Section 8.3.2, the perspective gathered from the foundational HP&C application in meso level is used to answer the overall research question. In practice, a service mentality with multi-level clashing motivations is typical, however, to suit digitalisation and collaborative environments, these motivations require streamlining by developing an investment mentality to unite risk perception. The links between meso levels, motivation, social climate, collaboration and digitalisation are discussed in this section.



1 – Overall, observable direct influence between meso factors on collaborative behaviour at the project level shown with empirical evidence established in results and validation
1A – Human Psychology and Culture in meso factors application; Section 8.3.1 discusses influences from bias
1B – The biases in decision making at the project level are dependent on the Human Psychology and Culture capabilities

Figure 57: Influence on Behaviour from Meso Levels and Hidden Aspects

8.3.1 Application of Decision-Making Psychology Theory to Meso Level Empirical Factors/Issues

Biases in decision-making from psychology literature are connected to observations made. The types of biases are reviewed and defined in Section 2.6.1.1. Section 8.3.1.1 centres on empirical observations and theoretical application on meso level 2 and Section 8.3.1.2 on meso level 1.

8.3.1.1 *Biases in Client Involved Decision-making* (Sujan et al., 2019)

The biases associated with the observed problems and the examples of emersion are shown in Table 25.

Table 25: Association of Cognitive Bias with Meso 2 Centred Empirical Evidence

Observed Problem (Combination from Table 24)	Examples of Emersion	Name of Cognitive Biases Associated	
		PB Errors	AB Errors
O1: The definition of client needs (EC6)	'The clients do not know what they want to achieve so it is hard to set goals';	Gain-loss	Myopic Problem Representation; Omission of important variables;
O2: Lack of client knowledge (EC1, EC7, EC10)	'Not enough skill in the clients to move to value-based procurement';	Gain-loss	Overconfidence; Myopic Problem Representation; Omission of important variables; Confirmation;
O3: Perception of teams having strong financial goals (EC2)	'Clients feel that there is catch but you cannot see it, they think the building industry is all about making money out of the client'	Gain-loss	Availability/Ease of recall
O4: Openness about finance (EC8)	'Blind spot in extra work, it can be looked as a modification or not, it brings arguments'	Anchoring	Confirmation; Overconfidence;
O5: Inefficient financial model to foster collaboration (EC4, EC6)	'Penalties for scheduling, we are trying to adopt reward based system'	Anchoring	Overconfidence
O6: Lack of flexibility in client needs (EC6)	'The BIM manual that the client provides is high in detail, no-one uses it, they are too detailed'	Equalising Bias	Myopic Problem Representation
O7: Lack of use of new contractual models (EC4)	'Reluctance from clients to use new contracts'	Gain-loss;	
O8: Enforcing client attitude (EC2, EC5, EC7, EC9, EC11)	'The client didn't try to promote and create a cooperative environment and made controlling decisions based on a fixed budget' which made teams stuck'		Confirmation
O9: Personal liability (EC3)	'Counting every cent' as the decision maker is personally liable and not made to feel protected'		Affect Influenced

8.3.1.1.1 Psychophysically Based (PB) Cognitive Biases

The gain-loss bias emerges when participants explain that some clients do not want to follow the new contractual models such as Integrated Project Delivery (IPD) based on the possible negative connotation brought about by the normative belief of firms being driven by individual financial goals (EC2 from Table 25) resulting in lack of client-based trust. Some participants mentioned the need to change this mindset as clients feel that 'there is a catch' even if teams appear to be open about finances. Gain-loss bias applies as there is a lack of certainty or information (equivocality) which makes the client base decisions on heuristics rather than real time information. Furthermore, partially due to the same negative connotation, some clients choose their own firms (EC4) driven by the perceived need to control behaviour (control belief); however, more often than not they end up spending more on the project. For example, the client chooses its own contractor often based on price (discouraged by many authors, such as Wong, Holt & Cooper (2000) but does not consider important factors such as whether the contractor and designers are going to be able to collaborate efficiently or whether the firm is capable to deliver the service. Participants from Study 1 explain that sometimes the teams are contracted before the Project Management (PM) firm making modifications bring about arguments over finance resulting in a non-optimal solution for clients. Additionally (due to normative and control beliefs), participants from a PM firm explain that some clients that do not take a leadership role on the project often position themselves at the centre of contracts bringing about loss of power to the employed PM firm (EC4); the appointed lead firm loses leverage which results in less financial control creating inefficient leadership.

At the project level, negotiations based on extra works are ones that clients and lead management engage in as changes are made. Participants explain the lack of certainty in defining what consists of extra works present in the contract bringing about the need for negotiation (O5 from Table 25). Furthermore, these extra works are perceived as a source of financial penalty to a team or the client, a normative belief. However, participants explain that there is need for rewards for extra work to encourage development of optimal solutions and the use of innovative processes. However, normative beliefs seem to hold back this possibility in many projects.

The anchoring bias inflicted by the firm presenting an extra works claim depends on the relationship with the client and the way the client reacts. Empirical evidence suggests that for a budget-strict and non-trusting client, firms could make use of the extra works claim to gain for the losses earlier made utilising the anchoring bias. Additionally (in the traditional contract), since the needs of the clients are relatively uncertain at the beginning of a project, the anchors used in financial estimation of objects that depend on the needs are suggested to be incorrect (O4/O5) as teams follow the normative belief that extra work result in a risk to lose profits. This results in a higher uncertainty to the firm in the tender process; an example of the overconfidence bias presented below.

A public client with numerous AEC projects (Study 2) defines the way information should be shared between teams. Contractors explain that the instructions to share information are too specific showing that the level of importance of each part was similarly weighted; everything was deemed as important. The client's control belief can be perceived to drive the inflexible demands. Furthermore, when a client was questioned about the manner in which their needs are defined, the participant admitted that at times needs are not clear as clients themselves do not know what they want (O1, EC6). Alleviating the bias is the normative belief that the firms providing a service to the client are more advanced and therefore capable (confirmation bias); bringing about a gap between what the definition of client needs and industry-based capability to provide for needs. The lack of clarity of needs brings about the assumption that needs are all important (similarly weighted) making the equalising bias cause further alleviation of this hidden problem.

8.3.1.1.2 Association Based (AB) Cognitive Biases

The availability bias

An example of empirical evidence associated with this bias is the common perception of firm financial goals in the industry as explained under gain-loss bias. This normative belief comes about as a result of past experience of the client and creates inefficiency by impacting decision-making. Since this common perception affects how the client trusts the teams on the project, this brings about less openness and a negative collaborative environment was explained to be more probable. Furthermore, on a positive note, a participant explained that an experienced client firm began utilising IPD, which resulted in a better project and therefore, the client began to demand IPD in future projects; overstated as in the availability bias. This relates to the prediction of Ajzen (2002); the impact of past experience can vanish with strong, well planned intentions and realistic expectations.

Myopic problem representation bias

In this context, empirical evidence suggests that the client over-simplifies their needs due to the lack of knowledge (O2, EC1, EC6) and experience. This is explained to be more evident when using BIM in facilities management as the way building parts are modelled needs to reflect their use. Data suggests that the mental structures utilised in project delivery is done in accordance with the roles of firms in design and contracting; there is no need to consider the entire lifecycle of the building and there is no financial motive. Therefore, decisions are made based on a gap between what is realistically needed to suit the operations of the building and the solution to the client. Alleviating this is the lack of client knowledge bringing about the lack of foresight to make this critical in the beginning of the project. Additionally, one participant explained the paradox in some client needs where 'definition of needs is to be done before knowing the realistic needs in the particular context' showing that there is an ever-changing mental model which results in over-simplification and therefore a non-optimal definition of needs.

Omission of important variable bias

This could be as a result of the myopic problem representation bias where simplification results in omission. Empirical evidence similar to the above presented can be used to back the application of the bias as this results from the lack of client knowledge and therefore the insufficient coverage of needs (O1, EC6) resulting in alleviation of consequences.

Overconfidence bias

A public client who delegates the manner in which BIM is used produces a BIM manual. Participants explain how this manual is too technically detailed and specific therefore bringing about overconfidence bias in the form of over-precision. Furthermore, when budgeting, strict financial management was said to more likely result in poor project success. When questioned about the reasoning for stricter financial management, some participants believed that it was because the client overestimated his/her own ability in planning the budget (EC8) - commonly perceived as a non-dynamic process resulting in disappointment when changes are inevitably made. Further, this also involved lack of trust of firms (from the common financial belief presented in gain-loss bias) where clients tended to assume that the stricter they are, the more they would save (gain-loss bias). Plus, the client tends to overestimate the contract's ability in defining extra works; participants explain that there is uncertainty in what constitutes to be extra work that is claimable which results in disputes and negotiation, which tests trust between the client and teams.

8.3.1.1.3 Association Based (AB) Motivational Biases

Confirmation bias

From a focus group, an example with a public client revealed that the confirmation bias may be present in some clients. A public project with a fixed price contract was managed strictly (overconfidence bias) which resulted in the project going over budget and over time resulting in it being halted. During this time, the client was said to be not supporting collaborative working methods and was not open to change, participants believed that this may have been due to the normative belief that the firms want to make higher profits (O3) and the perception that this way of working was normal in the industry and has been done successfully in the past. This resulted in a lack of trust between the client and teams which forced the client to halt the project. A change resulting from new client representation which supported collaboration and cooperation with less focus and more flexibility in the budget (EC8, O4) improved dramatically the likeliness for project success. Furthermore, a consultant explained that clients have a habit of not allowing changes in the budget early in the process of design and this results in later changes which end up costing more (EC10, O2). When questioned why the clients behave in this manner, the confirmation bias was brought about as various normative/behavioural beliefs (such as perceiving the teams have solely financial goals and enough knowledge to provide accurate overall financial estimations) were explained, resulting in lack of trust between client and teams.

A public client explained that there is a common normative belief in their organisation that the firms in the market are ahead of the client in terms of capability and understanding due to the lack of knowledge about the market (O2). This is an example of a belief that brings about unconscious assumptions (e.g., high expectations) when decisions are made by changing the perception of evidence provided; confirmation bias.

A representative from a project management firm explained that when the client does not set up contracts in a manner that gives the project management firm enough control over other firms by giving the leader enough leverage, this can result in higher costs. The client puts itself in a position of financial control based on the belief that they would be more in control of the project (O8), although the client may not have sufficient knowledge and involvement to be in that position (O2). Based on this belief of false control, the participant explained that the lead management firm ended up being held accountable as the client used evidence based on normative beliefs, assuming the firms could have done it with respect to the high expectations.

Affect influenced bias

A participant from a project management firm explained that clients that are utilising personal funds tend to 'count every cent' (O9); claiming that this brings about higher probability of conflict as clients tend to feel that firms may be trying to make higher profits (O3). This is a common phenomenon, emotional attachment to a product tends to affect decision-making negatively. In the mobile phone industry, Nokia's top managers were found to have emotional attachment for utilising their originally developed innovation whilst competitors developed other innovations and took over the market share (Vuori and Huy, 2016). Similarly, emotional attachment to one's finances affects decision-making as investment in project-based innovations requires early investment of time (EC10); e.g., scripting of repetitive tasks at the early design phase to avoid repetition when changes are made later in the project require high resources early. Therefore, these changes in the budget are ones that the client should agree to, however, commonly not; the lack of foresight of some clients resulting from lack of knowledge and high expectations.

8.3.1.2 Biases Inflicted by Contracts, Business Models, and Procurement

The biases from psychology theory which are related below to the empirical evidence are summarised in Table 26. The biases are defined and reviewed in Section 2.6.1.1.

Table 26: Cognitive and Motivational Biases related to Meso 1 Centred Empirical Evidence

Empirical Issue (extract from Table 23)	Name of Biases Cognitive Associated		Name of Motivational Bias
	PB Errors	AB Errors	
Misalignment of Business Model and Digitalisation inflict different project level behaviour (EI1)*			Affect Influence
Heavy liability contracts, lack of rewards – sharing liability and reward (EI2)*			Undesirability/Desirability
The service mentality – the need for investment mentality (EI3)*			Affect Influence
Industry fragmentation (EI4)*			Affect Influence
Differentiating innovation in project lifecycle (EI5)			Affect Influence
Contractual nature of addressing collaboration (EI6)*	Equalising, Certainty Effect	Omission of important variable	
Non-Relationship focus of team selection (EI7)*		Myopic Representation	
Discrepancy of tender information and reality (EI8)*		Overconfidence	
Non-personality/team chemistry based selection (EI9)		Myopic Representation	

*expert validated

Liability based contracts (EI2) have been related to higher probability to a blame-based environment alleviated or restricted by the cultural aspects of the team environment set by the leader and teams (depending on the way contracts are followed). The undesirability bias explains the tendency for teams to appear conservative towards sharing information and taking on risky activities when contracts are liability based; to avoid fear of blame. On the other hand, desirability

bias could explain the tendency for teams to share more information and take on risky activities when there is more trust in other teams and the leader (with financial leverage); the team trusts that the leader would understand circumstances when resolving conflicts.

The contractual nature lacking in rewards alleviates the probability that undesirability bias affects decision-making. The impact of more rewards would increase desirability bias. Increasing this bias would suit collaboration in a digital environment that involves significant inter-team innovative activities.

The 'professionalism vs profit' dilemma (Barrett, 2018) is in line with the empirical issue founded on the misalignment of the business model and needs of digitalisation (EI1). From the empirical evidence, lacking business model integration and the need for integration of digitalisation presents a dilemma bringing clashing behaviour. Empirical evidence of contractors agreeing to digital requirements in the contract and not being able to follow through are found. This shows that there is a tendency to focus on the profit element to ensure company profitability in a professional manner by showing irrelevant investment e.g., IT hardware, keeping in mind that typical clients lack knowledge of team environments. When considering biases, it is important to note the personal contracts of individuals are with individual firms and not with projects. Therefore, the tendency to focus more on their firm's profits can be connected to the affect influence motivational bias; the emotional predisposition for the outcome affecting oneself depends on the outcome of the firm the individual is working for.

The service mentality (EI3) arises partly as a result of the fragmented nature of the business model (EI4) and the way that contracts are made for portions of the project; separating participants from phase to phase to reduce individual risk. The empirical evidence allows the argument to add to the affect influence motivational bias where teams tend to only think about their particular goals in a phase of the project resulting in lacking consideration of other teams' solutions. This is evident with the poorly structured information delivery when a contractor requires to use the BIM or clients require it when needed for Facilities Management (FM).

Other evidence connected to the result of the affect influence bias is in the differentiating innovation in the project lifecycle (EI5). From Study 2, the designers were evidently more proficient in BIM than contractors. Furthermore, this is as a result of macro level aspects; e.g., the siloed nature of education and software industry. Furthermore, standardisation organisations tend to lack focus on some parts of the building lifecycle; contractors only represented 6% of certified participants in BuildingSMART certification (Hjelseth, 2019).

The contractual addressing of collaboration (EI6) is suggested to be poorly done in an enforcing manner lacking clarity of needs and expectations. The importance of the human centred factors of collaboration is lacking perceived importance suggesting an omission of important variable bias. Whilst collaboration and hidden factors are treated similarly to technical aspects suggesting the equalising bias. The Certainty effect can also be used to explain the preference of

technical aspects as there is greater surety in tangible/measurable outcomes. An expert explains the perceived lack of value of human factors as compared to similar industries e.g., defence and health care being in the occurrence of failure resulting to loss of human life. In the AEC industry, human factor risks (apart from safety culture in a small group of lifecycle participants) result in smaller events which affect cost and scheduled time and therefore are left hidden and not regulated. In health care, there is a range of research into the human centred factors of collaboration (some of which can be found in Section 2.7.2). In the defence industry human factor regulation developed by the UK government exists (Gov.uk, 2014). The objective viewpoint gathered from this research allows the argument of whether there is myopic problem representation bias in industry regulators in addressing challenges of innovation and collaboration; an oversimplified representation of collaboration made up of overconfidence bias of technical aspects and omission of important variable bias in human factors.

Regarding procurement, the non-relationship (EI7) and non-personality and chemistry-based selection (EI9) can be used to reiterate the above myopic representation bias. The over-simplification of an effective collaborative environment is symptomatic in the typical over reliant price-based selection process; not all costs can be attributed to material and time.

The discrepancy of tender information and reality (EI8) can be symbolic of the profit vs professionalism dilemma where information at tender stage does not reflect practice. This is representative of shifting overconfidence bias from overestimation before to underestimation after the tender. Before the tender, the firm is motivated to provide information with the aim to win the project. However, after the tender, the firm is motivated to execute the project to increase its own profit.

8.3.2 The Meso Level Implication on Collaboration and Effective Digitalisation

8.3.2.1 Motivation in the Traditional Contractual Practice

Figure 58 and Table 27 show links between the contract, multi-level motivation and HP&C aspects to bring a better understanding according to empirical accounts and literature. In the literature, the majority of studies in motivation/rewards and social climate are independent of one another because of reductionist and positivist prone nature of research (Barrett, 2018). Although, literature exists that claims social climate as more important than the contractual incentives in achieving higher performance (Rose and Manley, 2011). From the literature and empirical findings it is evident that contracts have subjective aspects (Bresnen and Marshall, 2000b). This research brings forth an explanation that the perception of contractual aspects is interrelated with the social climate a result of HP&C factors. It is important to note that contracts still have an impact on behaviour via extrinsic motivation (both at organisational and individual levels) and HP&C factors e.g., Study 2 public client explains the difference in behaviour inflicted by fixed price and hourly paid designers (Figure 58, Link 8). However, it is not valid to simplify that contracts are

solely affecting extrinsic motivation of teams but can be perceived as filtered by aspects rooted in HP&C that bring the social climate and the translation of organisational motivation to individual motivation (Figure 58, Links 10 and 1). Another reason for not making this reductionist assumption is that the organisations are extrinsically incentivised by contracts, and individuals working on the projects are extrinsically incentivised by the firm (Mullins, 2007; Osabiya, 2015); further increasing complexity bringing in dependency of macro level phenomena like organisational culture or hierarchy.

The interdependence of the social climate and the perception of the contractual aspects can be used to explain the positive effects of IPD and partnering initiatives. Since, in these contracts, risk and reward sharing bring closer collaboration, it can be hypothesised that the social climate is more stable as the perception of liability and reward is more united. Even though a more relationship focused procurement method is used, it is important to keep in mind that the rooted factors in HP&C (e.g., belief), need to align with the expected way of working, or there may be a risk of traditional culture applied in a different context.

The impact of intrinsic motivation on collaboration and digitalisation comes from the need for individuals to do what is needed for the industry to progress i.e. professionalism (Barrett, 2018). Although intrinsic motivation was not directly mentioned by any of the participants, it is inferred because of the enthusiasm and passion brought about by many participants. Professionalism clashing with extrinsic needs of the individual's organisation (profit) brings about dilemma in the behaviour of project level participants (Barrett, 2018). Using the simplification made in Figure 58 it is inevitable that since the contract has subjective elements, the motivations of individuals are reflected in the social climate of the project e.g., the normative practice of contractors making claims by finding errors in design hampers their relationship with designers (Figure 58, Link 2); therefore the social climate.

In summary, some parts of the contracts are subjective and therefore, the HP&C artefacts identified such as belief, personality that affect social climate, are affecting the decision making process in determining actions based on the contract both by the leader and other teams. Barrett (2018) observed and explains that in design teams an outgroup and ingroup can form which means that some teams are left out of some decisions, and therefore, compromising their position towards effectively delivering a solution. From the empirical data, tribalism, differences in personality, expectations, beliefs etc. can all contribute to the disparity between teams and therefore affecting the decisions subjectively based on contracts. Project level team motivation can be defined as an aggregation of multi-level (e.g., organisational and individual) extrinsic and intrinsic motivation with a dependency on the project's social climate made up of applied HP&C, organisational, client and contractual influences. Therefore, singling out optimising extrinsic motivation driven by contracts is inadequate in achieving high performance project teams. However, with initiatives to achieve positive social climates, there is a higher probability in

improving project level performance. This could explain the positive feedback from the use of partnering and alliancing procurement strategies when implemented appropriately with the social climate given importance (Walker and Lloyd-Walker, 2016); people have to be the priority e.g., in Study 1 Alliance projects have teams selected based on existing relationships increasing the probability for a better social climate. Initiatives need to be taken in ensuring that teams can achieve a positive social climate, from empirical data, this is not possible with all teams; the HP&C factors need to be united, approaches to assess them before tender stage require development.

In Section 8.3.2.2, the ideal mentality to digitalise brought about by uniting the extrinsic motivations between client-teams, team-team, team-organisations is needed. Although the extrinsic motivation of individuals is clashing with their intrinsic need to be professional (Barrett, 2018), the extrinsic motivation of the individuals is filtered from the way their firms are extrinsically motivated by their project. Therefore, the unity of extrinsic motivation of both are significant in achieving and maintaining a positive project level social climate. It would therefore be valid to hypothesize that in a project, the unity in extrinsic motivation of individuals from various organisations is related to the nature of collaborative behaviour assuming there is unity in the way that the projects extrinsically motivate organisations using liability and rewards.

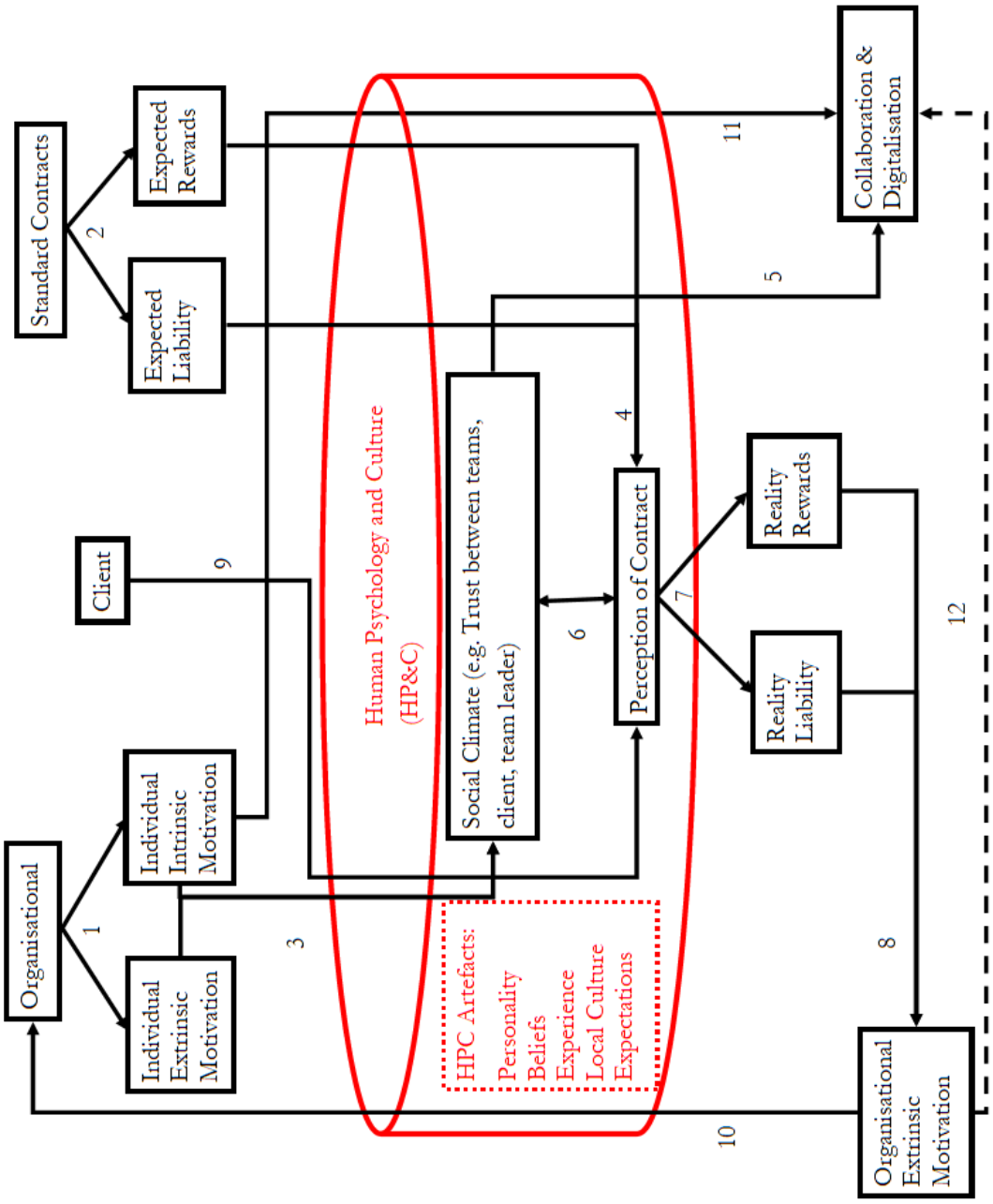


Figure 58: Motivation in the AEC industry

Table 27: Links Made in Figure 58, Literature and Empirical Support

Link in Figure	Explanation	Literature	Empirical
1	Individuals are contracted to organisations meaning that the organisation has superiority in providing extrinsic individual motivation e.g., benefits, security, promotions etc. Intrinsic motivation are also partly from the organisation e.g., psychological rewards, quality of work life etc.	Osabiya, (2015); Mullins (1999);	All study participants were contracted to firms, not to the projects
2 or 7	Liability and rewards are managed as stipulated in the contract however subjective in reality	Bresnen & Marshall (2000b)	Contractor opportunism uses the subjective parts of contract to underbid and then claim extra works where applicable - Expert 5
4	The contract is perceived differently, as aspects of it are subjective. The strictness or flexibility in perception is dependent on the project management or project leader	Bresnen & Marshall (2000b)	Strict use of contract negatively affects social climate and trust. Ambiguous aspects in contracts e.g., extra works. - Studies 1 and 2
5	Trust between teams is vital for individuals to openly collaborate	Section 2.6.7	Trust is vital in all levels of model - Studies 1, 2 and experts
6	The social climate impacts the way the contractual aspects are perceived and vice versa.	Rose & Manley (2011)	Social climate is dynamic at the project level, consistency of liability and rewards is needed to avoid disputes. Developing a positive social climate enables openness which reduces changes therefore less claims. Nature of work is interdependent bringing the question of which stakeholder is liable. Subjective aspects of contracts e.g., extra works or change orders - Studies 1 and 2
8	Contractual mechanisms put in place for extrinsic motivation e.g., rewards and rates	Section 2.4.1	Ways firms are paid, hourly or fixed price - Study 1, 2
9	The client's perception of the contract depends on their expectations and beliefs (meso level 2)	Che Ibrahim, Costello & Wilkinson (2015)	In study 1, clients that overcontrol projects place themselves at the centre of the business model restricting the PM leadership
10	Organisation is affected by project liability/reward and processes this is different ways in the industry creating organisation-based differences in exerting individual motivation	Bresnen & Marshall (2000b)	Contractors explain decisions by higher level management do not suit the project level representatives, bringing clashing motivations - Study 2

Link in Figure	Explanation	Literature	Empirical
11	Digitalisation and collaboration is motivated intrinsically in individuals	Barrett (2018)	No collaboration incentives in the contract, typically a requirement - Study 2
12	Overall simplified effect: Extrinsic motivation of firms are indirectly connected to digitalisation and collaboration		Leader without financial leverage has less power to motivate teams - Study 1

8.3.2.2 *The Idealised Practice*

Digitalisation of inter-team processes and outcomes is systemic in nature. Systemic innovation requires teams to integrate their processes collaboratively with respect to the needs of the innovative action at the project level. From empirical evidence, making this change requires investment in trust and learning between teams and the PM. This means that systemic innovation requires support from the independent organisations for its fulfilment at the project level. In this section, a service mentality is compared to an investment mentality. The investment mentality is as a result of more shared risk in the building lifecycle facilitating unity in extrinsic motivation of organisations. On the other hand, a service mentality in this context is defined as resulting in behaviour caused by separation of motivations (firms operating like services focused on their own role and risks) commonly in the AEC industry. These two mentalities are represented as a continuum between two extremes as shown in Figure 59.

The AEC industry, historically, has been developing in a fragmented manner to reduce individual firm risk (S. F. Sujan et al., 2016), which has enabled individualistic contracts bringing about a service mentality. From literature and data collected, it is confirmed that AEC firms typically operate as polarised services to enhance profits (Dulaimi et al., 2002) and therefore extrinsically motivated to think about their individual firm's objectives, posing clashing motivations; a hindrance to process unity at the project level. Chen & Kanfer (2006) find a parallelism between individual and team level motivation. This supports the link between clashing extrinsic motivations with clashing collaborative behaviour.

Study 1 represented a PM firm who are one of the most innovative in Finland, whose primary focus is to encourage teams to think more holistically about the project when achieving their own objectives. The firm did this by putting efforts in increasing trust between the teams, suggested as one of the key roles of the project manager. In the firm's ideal scenario, by creating trust, extrinsic motivations were aligned to a point where the contractual documentation would not be used to address disputes, it was only used in the unlikely case of litigation (which was avoided). This signifies the influence of the human factor signified by increased individual and inter-team trust.

From the data collected the capability of teams to holistically think is not questioned, however, whether they are motivated to think holistically is. Holistic thinking is incentivised by an investment mentality; brought about by motivation both intrinsically and extrinsically to think

about risks from a larger part of the building lifecycle. On the other hand, the service mentality lacks extrinsic motivation and relies on the intrinsic motivation for systemic innovation activities. For example, in an IPD the use of shared risk and reward can be considered as providing extrinsic motivation to enable holistic thinking in design and construction processes; this was found to reduce the likelihood for conflict and increase the likelihood for a positive collaborative project environment (Pishdad-Bozorgi and Beliveau, 2016). Additionally, in Study 1, client satisfaction was found to be improved. From Study 2, contractors explained the higher profitability in developing their own buildings serving directly to the end user as a result of increased integration which enabled a smoother innovative process. This suggests that digitalisation benefits from united risk perception across the building lifecycle.

The behaviour required at the project level, to efficiently develop interoperable digital models is different from the behaviour incentivised by the traditional business model; also referred to as the 'profit vs. professionalism' dilemma (Barrett, 2018). This difference comes from the nature of innovation changing over the last two decades with the new systemic nature brought about by e.g., BIM; it requires multiple firms to change practice in a united manner to be efficient (J. Taylor, 2005). The normative beliefs that the business model is built upon come from incremental innovations and have not changed drastically to suit the systemic changes in innovation.

In answering the RQ4 (how could the AEC industry increase project level collaboration by efficient implementation of digitalisation by focusing on the transactional aspects?); it is inevitable that higher integration in motivation brought about by new shared risk and reward initiatives such as IPD have had a positive effect in bringing a mentality to invest. A possible reason is a lower psychological distance between teams due to aligned risk perceptions and goals. The mentality to invest is needed because a firm's involvement affects the project in phases they are not involved in. This mentality to invest brings about increased incentive to process changes that requires learning and intra-organisational support for systemic innovation adoption such as BIM. Empirical data regarding shared risk and reward also found a lower psychological distance between client and teams when there was higher unity in risk perception, resulting in increased ability of the client to trust teams; exemplified by the increased client satisfaction in Study 1 from procurement strategies that share risk and reward. However, the psychological distance between client and project level teams still exist; currently, the client gains or loses based on the building lifecycle whereas teams gain or lose based on the project lifecycle. To further complicate reality, most clients are not technically competent to define the requirements for later phases of the building lifecycle. Facilities Management (FM) is said to be seven times the initial investment costs (Lee et al., 2012) or three times the construction costs of a building (BIM Task Group, 2013), signifying the high potential savings in FM and building lifecycle costs if digitalisation is

successfully implemented. However this success depends on the collaboration and unity of teams earlier in the lifecycle.

Numerous pieces of literature highlight the difficulties of BIM use in FM pertaining to the lack of foresight of teams in developing the BIM and lack of client technical knowledge (Becerik-Gerber et al., 2012). The empirical data also shows this especially from the Norwegian public client which explains the unstructured nature of FM information. In this discussion it is raised whether these challenges could be resolved by incentivising teams to perceive risks and think holistically like the client by being motivated by rewards from the building lifecycle rather than parts of the project lifecycle.

It is evident that there is a need to encourage an investment mentality to suit the systemic nature of digitalisation and with respect to the biases found based on empirical evidence, a number of observed problems can be resolved if the teams are incentivised to think similarly to the client about an asset (rather than their own role). The lower psychological distance between client and teams enables clients to trust teams more as they can perceive that the teams have similar interests to them and therefore, enables better exchange of value. For example, the client's lack of technical knowledge in their own needs could be reinforced by expert team advice, enabled by more trust as a result of united incentives. On the other hand, a firm's knowledge of other teams can be used in procurement to enhance inter-team cohesion. This mentality also enables the project team to take risks associated with innovative environments resulting in higher propensity to innovate systemically. But first, teams need to be motivated and align risk perception to the client to allow the relationship to strengthen with more trust.

Figure 59: Service vs Investment Mentality

8.3.3 Overview of Links Made in Part 2

Figure 60 shows an overview of the links made in this thesis from both the literature and empirical data.

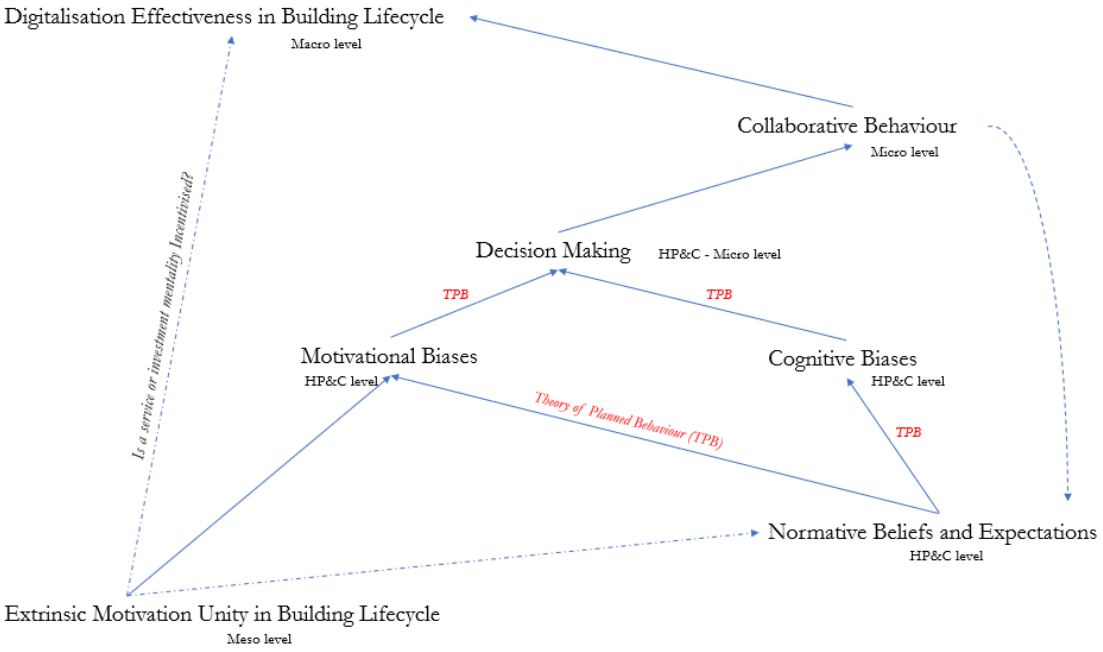


Figure 60: Links Between Phenomena

From empirical data and literature, it is confirmed that the contracts can be viewed and used in multiple ways depending on the trust between teams and the leader (Strahorn et al., 2017). In certain cases when trust is positive, the contracts are not referred to, therefore the focus should be on extrinsic motivation where the contract is a tool used to enable clarity in perception of them. Reiterating that the process is socially rooted, where contracts are to be perceived as guides and to be used according to social contextual factors.

From empirical evidence psychology decision-making theory was applied; Section 8.3.1.1 shows the biases by a focus on the client and Section 8.3.1.2 shows the biases inflicted by the contractual and business model nature. Both sets of biases depend on beliefs as in the Theory of Planned Behaviour (Ajzen, 1985), and these beliefs are from historically repetitive practice making them culturally normative. The links between beliefs, biases and decision-making in this context are established and found to agree with TPB. Without drastic change or regulating the thought process as in defence HFI, it is hypothesized that these beliefs will not change.

The collaboration practices that include the way people behave and/or are expected to behave aggregate to traditions or established ways of working. Without agents (drivers for change) that cause repeated changes that reform practice fundamentally, these traditions continue to naturally develop limiting digital transformation.

Disunity in extrinsic motivation is found according to empirical data and literature:

- Client – team: A cultural normative is that the client is extrinsically motivated to think about the building lifecycle and project level stakeholders are only extrinsically motivated about the project lifecycle. This results in psychological distance between client and teams. From empirical data, contractors in Norway explain the higher profits and reduced difficulty in innovating in their internal assets where the contractor is also representing the client.
- Team – Team: Culturally normative is also the practice that teams are individually contracted, have individual risk and therefore forms psychological distance between the teams. Over recent years partnering, IPD, Alliance contracts are moving away from this tradition bringing sharing risks and rewards. Both literature and empirical data shows that IPD brings better collaboration and innovative action at the project level. Empirical data also suggests increased client satisfaction.
- Organisation – Team: Disunity of project driven organisational extrinsic motivation and individual extrinsic motivation as a result of individuals being employed by the organisations. The way individuals are extrinsically motivated depends on their organisation and differs from organisation to organisation.

Extrinsic motivation unity between stakeholders in the building lifecycle is indirectly linked to the digitalisation effectiveness in the building lifecycle. Facilities Management is approximately three times the cost of construction (BIM Task Group, 2013). From the BIM lifecycle, the interdependence between lifecycle stages shows that the quality of FM also depends on the project lifecycle development of BIM. From Study 2, only the public client brought up FM and clarified the need for project-based teams to adhere to the FM needs, although teams do not attain direct value from it.

Within the Project Lifecycle (PL), a Norwegian contractor explains that in most projects the quality of the Building Information Management Model (BIMM) handed from the design stage is often structured inappropriately for contractors in traditional project delivery. According to literature, the shared risk and reward in IPD and Alliance, helps resolve these difficulties by ensuring earlier involvement and a more positive collaborative environment (investment mentality) enabled by increased trust between stakeholder (Pishdad-Bozorgi and Beliveau, 2016). Therefore, the extrinsic motivation unity brought about from shared risk and rewards has united the approach of the contractor and designer to digitalisation in the project lifecycle. Similarly, uniting the risk perception between client and teams could improve the implementation of digitalisation.

Beyond the project lifecycle (keeping in mind that there is dependency between FM and PL digitalisation), there is need to unite extrinsic motivation of PL participants to ensure that risks are perceived regardless FM deliverables. It is predicted that if the psychological distance between teams and client reduces this would enable increased trust between client and teams.

As Bresnen & Marshall (2000b) find, it is important to recognize that the individual motivation is different from the organisation motivation. The project appoints firms and firms appoint employees to the project. Therefore, one element that did not emerge in the data collected was the firm's influence on individual's motivation, however, it is evident from literature.

8.3.4 Summary of Part 2

The meso level empirical issues and factors were reasoned with theories in biases in decision-making; reiterating the need for HP&C to be foundational when setting up a collaborative environment. The biases emerge with respect to normative, control and behavioural beliefs. These beliefs are from years of stagnant practice which define the multi-level expectations (individual, inter-organisational and industrial).

A key aspect looked at as part of the meso level is the motivation of teams and the client. Keeping in mind that digitalisation is systemic, and benefits appear to be more substantial to the client at the end of the building lifecycle due to higher cost compared to construction and initial investment. Therefore, an investing rather than service mentality is required for effective implementation of digitalisation. The investment mentality means more united risk perception between teams. The extrinsic motivation of firms (not the same as individuals) at the project level is typically from profits in deliverables within the project lifecycle; there is no extrinsic motivation for teams to think about digitalisation in the later parts of the building lifecycle. It is mainly driven by the individual intrinsic motivation to be professional and do good for the industry (Barrett, 2018).

Teams in the construction and design part of the building lifecycle are working like polarised service providers, fragmented to reduce individual risk by increased specialisation. A service mentality is compared to an investment mentality and shows that the investment mentality suits building lifecycle digitalisation. The service mentality is as a result of historical normative working with fragmented contracts, making changes to mentality rooted in a social and psychological change needed by digitalisation. However, drivers for the relevant social and psychological change are to be enabled by changes in the transactional (meso) part of the model as it affects when and how teams get involved. Fundamental changes in extrinsic motivation and mentality are required to align behaviour to suit that required by digitalisation.

Finally, literature and empirical data collected shows the importance of trust to enable positive collaborative environments (Pishdad-Bozorgi and Beliveau, 2016). The way that this link between trust and collaborative environments is complex in nature; motivations, beliefs, expectations all contribute to the bias in decision-making at the project level of both clients and teams, although, regulation can unite perception of value of these aspects as in the defence industry.

The disunity in motivation of stakeholders in traditional project delivery is connected to the collaborative environment partly because the contractual aspects are subjective and linked to

the social climate. Therefore, it is valid to hypothesize that there is a link between the disunity in motivation between stakeholders and their ability to trust one another; keeping in mind that IPD brings higher trust when extrinsic motivation is united enabled by sharing risk and reward. With a focus on relationships between stakeholders (Rose and Manley, 2011) perceptions of the subjective elements can be improved by bringing more trust enabled symptoms (e.g., openness). However, without fundamental changes in bringing motivation unity (both extrinsic and intrinsic), the high dependence on the quality of the social climate is arguably difficult to change. Teams will question the intentions of one another if they are not affected by project risk similarly. The dependence on the social climate brings a number of difficulties owing partly to the transient 'stop-start' nature of procurement. Furthermore, intrinsic motivation unity is also difficult to measure or comprehend and is most importantly found by experience in existing relationships e.g., through an existing relationship one could trust the intrinsic intentions of the other party. Therefore, the extrinsic motivation unity needs to be accompanied by allowing the procurement process to put relationships and people first. This may be one of the reasons that IPD has been successful in many cases, people are the priority allowing for rewards to reap further in the process; there is importance in remembering the right people on a project are an investment and their roles not oversimplified as a service, but this mentality has to be motivated extrinsically.

Beyond the scope of this thesis are the methods of getting teams to think with an investment mentality rather than as a normative service. This is raised in further research in Section **Error! Reference source not found.**. However, it is suggested that teams require extrinsic motivation from the FM part of the building lifecycle to make a transformational shift from the service like mentality culturally normative in the industry enabling better trust between teams and the client.

8.4 Summary

This chapter discusses the findings of this research. The first part (Section 8.2) compares the way human factors are applied in similar industries where practitioners collaborate beyond disciplinary boundaries. The second part (Section 8.3) began by applying psychological theory (biases in decision-making) in relation to empirical findings exemplifying the multi-level interaction of phenomena in the HMC-AEC. Organisational, client, contractual, social climate all formed a schematic of practitioner collaboration in Section 8.3.2.1. A reflection on collaboration, digitalisation, motivation and decision-making was used to discuss how practice could better suit digitalisation by enabling efficient collaboration in Section 8.3.2.2.

9. CONCLUSION

9.1 Introduction

This chapter provides an overview of the research outcome. The first part of the chapter (Section 9.2) provides a conclusion of the research with respect to the guiding 'CIFE Horseshoe Framework'. The aim is to provide an overall view of the way research questions are answered and to explain the contributions and impact of the research.

The second part of the chapter (Section 9.3) provides the researcher's reflection on the method, study, results and a personal account. This was introduced as suggested by scholars (e.g., Moss, Girard & Haniford, 2006; Lincoln & Guba, 1985) to bring out the researcher's bias in the research. The researcher's understanding and perspective contributed to the interpretation of the qualitative data analysed in this thesis.

Concluding remarks are presented in Section 9.6 to provide a short description of what, how and why the AEC industry could use human aspects in collaboration to make digitalisation more effective.

9.2 Part 1: Research Conclusion

The Figure 61 shows the structure of this section with respect to the adopted CIFE research framework. A review of the evolution in research questions and the findings is described in Section 9.2.1. The claimed contributions with respect to the theoretical point of departure and research gaps are presented in Section 9.2.2. The predicted impact with respect to the observed problem is presented in Section 9.2.3.

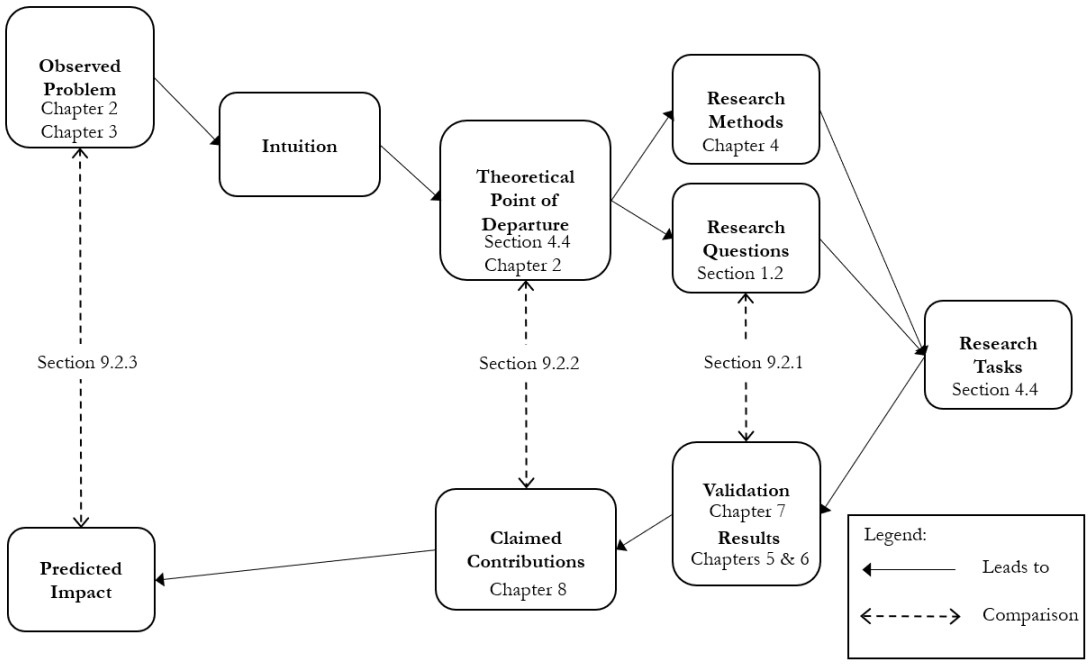


Figure 61: 'CIFE Horseshoe Framework' with Thesis Structure

9.2.1 Review of Aims, Research Questions and Methodology

The overall research aim was to understand the factors affecting project level collaboration and effective digitalisation by application of theory and reflection on knowledge interpreted from practitioner experience. The development of the research questions depended on the progression of the research project in achieving the overall aim; facilitating key changes to the methodological approach as per the development of the researcher's understanding of the complex topic.

RQ 1 (How can project level collaboration be studied?) resulted in the development of the exploratory study (see Chapter 3). The researcher was motivated from literature; calls for the development of performance metrics (Succar et al., 2012; Nasir et al., 2012) resulting in the ***SRQ1 (Can project level collaboration be measured?)***. The development of the exploratory study therefore involved a mixed methods approach to enable qualitative validation to a predesigned Quantitative Instrument (QI). The various studies in health care connecting performance to the perception of teamwork (e.g., Sexton *et al.*, 2006; Ødegård, Hagtvet & Bjørkly, 2008) motivated the development of the QI. Using intuition, the systemic risk part of the QI was developed with the hypothesis that practitioners with similar perceptions to risks that affect all teams would collaborate better. The motivation for combining these two metrics was to develop the perception of systemic risk as an indicator for efficient team selection.

The exploratory study concluded that the variance in perception from the QI was higher for the less collaborative project although lacking statistical validity. The lack of statistical validity was brought about by the behaviour of firms where only one or two members of a team engaged in exchanges between teams. To answer SRQ1; project level collaboration can be measured, however, due to the statistical limitations the constructs of systemic risk and teamwork environment require design with greater precision.

From the qualitative data, the complexity of project level collaboration became inevitable as the researcher discovered the high interdependence between phenomena. This resulted in ***SRQ 2 (What methodological paradigms are suitable to understand the reality of project level collaboration?)*** facilitating the methodological reform towards a critical realist paradigm allowing the deductive interpretation of collaboration to induce a model for understanding. This methodological change is also supported by the research gaps (Section 2.7.4) encouraging the transfer of knowledge from practice to academic literature (Moum, 2008) in a holistic manner (Phua, 2013).

The primary aim of ***RQ 2 (How do collaboration factors result in project level behaviour?)*** was to understand the existence and dependency of project level collaboration factors. To make this research question into manageable tasks, it was broken down into four sub research questions. ***SRQ 3 (What factors affect project level collaboration according to project level practitioners?)*** aimed to identify the factors according to practitioner perspectives put across in the qualitative data collected. The content of the qualitative data involved a wide

array of factors reflecting the semi-structured form of interviews and focus groups; allowing for practitioner views to be put across in a flexible manner depending on their experiences. Table 15 shows the coverage of the most common themes across the different project perspectives. The variety and complexity of the interdependence of these factors requires categorisation to facilitate understanding resulted in ***SRQ 4 (How can the factors that affect collaborative environments be visually interpreted?)***. The micro (inter-organisational), meso (transactional) and macro (intra-organisational or industrial) categorisation was used. The meso factors consisted of client and procurement/contractual factors. The data collected showed dependency of the procurement/contractual factors on the client factors. However, there were factors either that did not directly fit into any of the categories or fit into all the categories. All of these factors formed a part of the reasoning for current practice. These were put in a category called Human Psychology and Culture (HP&C) which formed the foundation to the micro, meso and macro classification. The decision to use these categories assisted in structuring the explanation of complex and highly interdependent data in the Holistic model of Collaboration in the AEC industry (HMC-AEC).

The next challenge was to select where it would be most practical to focus the objectives of discussion based on the data collected owing to the richness of data collected. ***SRQ 5 (Which factors are most practical to change and impactful in driving industry wide change to suit project level collaboration and implementing digitalisation?)*** was therefore developed. Three variables were used to guide the decision (also validated by experts); the time taken to change, controllability and systemic impact. The meso level was selected because it facilitates practical changes and reasonable impact.

SRQ 6 (How do expert views from literature and practice compare to project level views?) was developed to ensure that the observed problems and factors were perceived with respect to reality; to show that the unavoidable researcher's bias did not completely change the meaning of data collected. Furthermore, the expert interviews and literature would give the researcher an idea of biases in the model developed resulting in gaps within the data collected. The structure of the HMC-AEC and meso centred observed issues were validated. The experts were able to relate closer to the root causes of project behaviour and therefore showed gaps in the main study's data.

RQ3 ***(How could the AEC industry increase project level collaboration by efficient implementation of digitalisation by comparing to similar industries?)*** was developed to bring in external perspectives that validate the HMC-AEC foundation and was split into two sub-research questions. ***SRQ 7 (How are factors rooted in Human Psychology and Culture valued in the industry compared to similar industries?)*** was developed to understand the way similar industries value human factors as a result of the foundational emergence in data collected. From this, it was clear that human factors in the AEC industry are

not valued as much as in the health care or defence industries. This may be because the defence and health care industries have more direct risks to human life whereas in the AEC industry, the consequences are increasing cost or time taken to the client (with the exception of safety on site where human factors has been applied widely). From health care literature, the hidden nature of human factors is suggested to bring an intangibility bias which means that researchers and practitioners tend to give more importance to factors that can be directly observed or measured. This could explain the lack of perceived value and technical orientation of CM academic literature.

SRQ 8 (How can AEC collaboration models be adapted to suit realistic nature of factors?) was developed to transfer knowledge from similar industries' approaches to dealing with human factors. From the UK defence industry, the Human Factors Integration (HFI) framework increases awareness and provides practitioners with an overall understanding connecting technical and human factors. By doing so, it unites the project management approach in perception of risks from the hidden aspects of human factors. In the health care sector, the biopsychosocial approach has been added to the academic curriculum to develop the holistic perspective of its practitioners. The AEC industry needs to reflect on these approaches by developing policy and changes in its education curriculum to increase the awareness of the hidden influences of human factors by which the HMC-AEC developed in this thesis can be used as a starting point to frame the policy. Furthermore, the existing frameworks such as the IDDS (in Figure 1) would better represent reality if it were modified to have a foundational level taking into account human capability such as in the HFI framework.

RQ4 (How could the AEC industry increase project level collaboration by efficient implementation of digitalisation by focusing on the transactional aspects (meso)?) was developed to facilitate the use of holistic understanding of project level collaboration to application in practice. The meso level was selected in SRQ 5 as the most practical level to focus theoretical application and reflection. ***SRQ 9 (How are the psychological and social aspects affecting project level decision-making and collaboration at the meso level?)*** connects the observed problems surrounding contracts and clients to biases defined in the psychology domain. By understanding the common beliefs in the AEC industry different types of biases are related, allowed for by the Theory of Planned Behaviour (Ajzen, 1985). This process exemplified the use of the HMC-AEC and the holistic understanding that enabled practice-oriented challenges. ***SRQ 10 (How is the meso level affecting the mentality of collaboration and implementation of digitalisation at the project level?)*** is developed to use the holistic understanding gained in the research to provide a perspective on current collaboration and digitalisation. It is suggested that there needs to be greater unity in motivation between project and building lifecycle participants. The increase in unity is already occurring in the project lifecycle with more partnering, alliancing and new procurement approaches such as IPD. However, to suit digitalisation in the building lifecycle and maximise savings in FM, the teams' perceptions of risk

need uniting to provide an effective solution to the client. Currently, typical teams are operating like a service, but digitalisation requires them to invest in creating a lifecycle efficient integrated solution. This change in unity of motivation is partly a change in how businesses create value and operate (business model). From Downes' law, a business change helps facilitate a social change meaning that business operations frame some socio-cultural expectations. To facilitate unity in motivation, the understanding of motivation was developed by defragmenting factors; a schematic of practitioner motivation is developed to combine various factors that affect the receptiveness of practitioners towards innovative action. The complexity of extrinsic individual motivation is evident as it depends on the subjective nature of contract use, the social climate of the project, organisational factors, client behaviour and the way standard contracts are created.

The HMC-AEC model developed in this thesis provides a bigger picture of the emergence and concepts involved in project level collaboration as needed to answer the overall RQ ***(What could enable efficient project level collaboration and efficient implementation of digitalisation in the AEC industry?)***. To enable efficient development of innovation there is need for a holistic understanding, this is because of the high level of complexity of the interdependence between factors surrounding project level collaboration. By taking a holistic and systemic view by visualising the interactions in the HMC-AEC, this can facilitate a better understanding to ensure innovation can be implemented considering multiple factors at multiple levels (project, industrial, psychological, social etc.). This is a gap that has been found in literature where there is a need for holistic, integrative frameworks to give researchers and practitioners the perspective to frame their sensemaking.

A more aligned answer to the overall RQ can be found in Section 9.2.3 as it applies to practice. In answering the overall RQ, human factors require significant focus in relation to digitalisation implementation in collaborative practice There is a certain link between the two. The research has provided reflections from similar industries to exemplify ways to raise awareness and enable practitioner appreciation and understanding of human factors. Understanding the impact of technological change on collaborating people and their current practice is valuable. This is because people need to be receptive to the changes in process and environment that suit digitalisation. Furthermore, understanding why people behave or are motivated in the current practice and whether this suits systemic innovation is required to gain positive belief and expectations. The lack of unity of motivations in the building lifecycle was one of the significant challenges that need overcoming. This is because, the systemic nature of changes need teams to collaborate more efficiently as the complexity of industry needs increase and normative practices become outdated; people need to be motivated to be open facilitated by having unity in risk perception. In answering the overall RQ, a holistic perspective was developed which enabled interaction between various concepts. This interaction signifies the added value from this research, as it enabled research reflexivity as common in the critical realist paradigm.

9.2.2 Research Contributions

This section collates and summarises the contribution of the research to the Construction Management (CM) domain in academic literature.

The point of departure (see Section 4.4) consisting of an interdisciplinary array of theories from social science, psychology, complexity science and business was applied to the context of digitalisation and collaborative practice in the AEC industry. This contributes to the research gaps by defragmenting knowledge (Smyth and Pryke, 2009) and bringing an industry practice based perspective to academic knowledge (Moum, 2008; Volker, 2019). Facilitated by the methodology and approach taken in data collection, experiences of practitioners surrounding collaborative practice were analysed. The design of the research methodology was flexibly developed with respect to the development of the researcher's understanding from literature, the exploratory study and main study; the reason for multiple reality-driven sub-research questions.

The exploratory study tested a metric and showed that it is possible to correlate numerically collaborative practice although, due to the low statistical validity, there is need for greater precision in constructs used. The variance in data collected was higher in the lower collaborative project. This study was significant to the research as it made the researcher understand that there is a need to understand practice holistically from industry practice based perspectives.

From the lessons learnt in the exploratory study, the method of the main study facilitated understanding reality using rich qualitative data that grasps the complexity of reality. This enabled the induction of a model. Moum (2008) used micro, meso and macro categories to structure explanation of collaboration between designers, this was used to structure the developed HMC-AEC. This research takes this further by adding a foundation on Human Psychology and Culture (HP&C) which was evident from the interdependency on e.g., human beliefs, expectations or personal characteristics of micro, macro and meso factors. This addition is externally validated from Ajzen's Theory of Planned Behaviour (TPB) which explains how individual beliefs based on socially driven individual expectations affect decisions made. Furthermore, the defence industry has a Human Factors Integration (HFI) framework where the capability of human beings is used as the foundation to practice. Similarly, the psychological and social capabilities in the HMC-AEC are described as being foundational. The novelty of the model is in it's structure placing human phenomena at the foundation and it's multi perspective (industry, project, client, contracts, psychological, social) which are shown in this thesis are highly interdependent. The model can be utilised to think about multi-level phenomena that can be used to bridge the gaps between knowledge by mapping the interactions within this model as exemplified by the cases in Chapter 5 and 6. Therefore one of the contributions of this thesis is in the analytical methodology of mapping interactions to facilitate holistic understanding. It is therefore in the process of mapping as well as the map itself that enhances this understanding.

This multi-level model presents a holistic view of practice, symbolic of the understanding gathered which enabled:

- Empirical accounts of problems driven by client behaviour or inflicted by contracts, procurement and business model (see Section 7.5)
- The defragmentation of knowledge by combining phenomena to develop a schematic of practitioner motivation. The combination involves organisational, client, project social climate, standard contractual forms etc. (see Section 8.3.2.1).
- Interdisciplinary connections by using observed problems from empirical accounts to connect biases in decision-making by applying psychological theory (see Section 8.3.1)
- Reflections on how the industry can reform business models to suit digitalisation and collaborative practice (see Section 8.3.2.2)
- Reflection from more mature industries in the way human factors are utilised (see Section 8.2)

In summary, the research's contribution reflects the philosophical paradigm used. The contribution is in the interaction of phenomena reflecting on real life accounts of industry practice.

9.2.3 Research Impact

Globally, industries are following common patterns, ICT investments not being reflected in productivity (Leviäkangas et al., 2017). There is a challenge in securing acceptable levels of efficiency and productivity (Li and Liu, 2012). Additionally, the global commonality of patterns and challenges in digitalisation and collaborative behaviour is validated by two expert views who explained the 'global nature' of challenges; they explain that human factors are rooted the same way, although how they are applied may differ according to local industry conditions.

The research impact according to the experts was:

- Awareness of the importance of human factors and the complexity of factors; the need to think about factors in an ecosystem rather than prevalent isolation of technical and visible aspects.
- Awareness to disciplines of the need to think about the solution with respect to the needs of the client and other teams. The HMC-AEC can assist practitioners to give them reason to think holistically about the solution being developed and not only the needs of one discipline; to help consistent understanding of the solution.
- The HMC-AEC can also be a reflective tool, to assist practitioners to see where the project could have done better and take lessons to the next project.
- Educational impact is in the ability of HMC-AEC to show a holistic view of complex interdependent factors. Used as a visualisation tool, experts indicate that the model can allow increased understanding of practice to students in university and practitioners as

part of training in human factors. The model can be used to reflect on project characteristics and set up, considering multiple aspects as in reality.

- Current relevance of model; mental health, corporate social responsibility and social well-being are increasingly given attention, the model could help strategy makers understand the role of the HP&C level.

The HMC-AEC and findings bring better understanding of human factors which can help avoid disputes, the industry is litigious as a result of disputes that can be prevented. Practitioners involved in the current AEC industry practice are facing a shift from 2D document-based tools to Building Information Management (BIM) requiring a paradigm change. Current practice is a mix of both BIM and 2D document-based tools (Moum, 2008; Harty and Whyte, 2009) where designers are more advanced than the typical contractor. Collaboration between teams is essential because the BIM processes require unified information structures. The established expectations that accompanied the long-standing use of 2D based documents is therefore evolving to suit BIM based ways of working. The difference between these expectations represents the paradigm change. In essence, the paradigm change is making the technical and social dependency more explicit as practitioners need to create open project environments for dialogues to establish clarity in expectations. Developing positive project environments to enable open dialogue between practitioners depends on many aspects, which is why a holistic model was induced in this thesis. Although this model has been made generic, its content represents a foundation for the development of policy and project strategy; the balance of phenomena in reality is very sensitive to missed considerations in developing strategy and policy.

The method developed facilitated the researcher's holistic understanding of industrial practice by understanding the foundational dependency on Human Psychology and Culture. The impact of the research is therefore a combination of practitioner perspective and researcher understanding gathered from the research on what could constitute improvements in digitalisation and collaboration practice. Table 28 shows recommendations to practitioners that can enhance collaboration and digitalisation.

Table 28: Recommendations to Practitioners at the Project, Industrial and Organisational Levels

Relevance	Recommendation	Reasoning
Organisational	Socially driven expectation management: Practitioners need a basic understanding of the human psychological and cultural aspects to establish united expectations on technical needs of the end product and BIM. A centred focus of implementing digitalisation on human psychological and social impact is needed.	Technology adoption requires relevant social and business changes. The use of technology is affecting information exchange between practitioners which changes processes and work methods. Impact of changes in work methods affects practitioners at a personal level therefore affecting their social well-being. It is important for individuals to understand the impact these changes have on them and other team members. Understanding the origin of bias can facilitate positive changes that help avoid biased decision-making
Organisational	Flatter hierarchies in organisations	Higher level management (people who control the finance) need to understand the socio-technical needs of the lower-middle management who use the technology. Collaboration inside a firm is not to be neglected and has impact on a project performance.
Organisational	Understanding the client and their project influence can help assessments of project risk when a firm is bidding for a project	The client is a key stakeholder, factors presented in this thesis are significant in relation to project risks. Their behaviour, decision-making approaches, procurement approach, style of leadership, technical knowledge all contribute to how risky the project is.
Project	Expectation management across the building lifecycle: Early involvement of major stakeholders from entire building lifecycle to develop BIMM and design needs.	Each stakeholder will have their own way of developing a solution, to ensure compatibility there is need for early exchange of expectations to generate needs. This is to ensure that the BIMM can be used without significant rework. From Study 2, the Norwegian contractor explains that usually, the BIMM is structured inconsistently and therefore needs significant rework before it can be used by them.
Project	Reducing the probability of adversarial behaviour by having a relationship focus from both client and project management, in developing procurement strategies and project processes.	By focusing on relationship-based procurement, it is more likely that high levels of openness between teams would occur. A highly open team environment reduces the fear of liability and reduces disputes by having a high level of trust formal barriers are broken. For the relationships to develop, time outside the formal project role is required for people to understand the way a person should be approached in the future.
Project	Project leadership to openly explain the behavioural	The firms and practitioners all have different expectations and beliefs that

Relevance	Recommendation	Reasoning
	expectations of project practitioners and the leadership at early involvement.	come from their discipline, their organisational culture, long standing normative practices. This means that expectations can vary. Clarity and openness in expectations, if received well, could contribute towards increased openness between teams. The Study 1 project management firm is one of the best in Finland and has an open culture, at the beginning of every project, the expectations are put forward openly. It helps facilitate cultural diffusion between teams however, this process can take time depending on whether there are other inhibitors e.g., individual openness to change, organisational expectations.
Project	Team selection to consider social climate	The selection of teams (at tender stage) should consider the social dimensions of a project team. Not all teams can trust each other, and existing relationships help build trust. Organisation culture of a firm is an indicator, however, there are other factors that can impact a team's social performance e.g., personal characteristics. At tender the information should be provided based on the individuals in the team.
Project	Responsibility to develop a project's Information Delivery Strategy (IDS) needs to be collaborative	If teams all feel that they have played a vital role in developing the IDS, it is more likely that they would adhere to its needs.
Industry	Standardisation focus to go beyond the definition of objects but to the definition of both tangible and intangible processes.	The way that objects in a BIMM are combined depends on both human and technical oriented factors. It is recommended that standards are developed considering the way humans interact and operate
Industry	Regulation of human factors (as in the defence industry) to unite the approach to management and operation of projects considering human factors.	Management practice to integrate delivery can vary significantly if there is no policy to streamline human aspects of process. Since every project involves new people working together, a policy can streamline project strategy. Furthermore, there is a need to raise awareness of the social and psychological barriers to adopting technology and changes in delivery.
Industry	Holistic perspective development e.g., training	Education also plays a part in creating siloed/fragmented mentalities. Practitioners require a holistic understanding to understand the way their personal influence can positively affect the entire project. Training in

Relevance	Recommendation	Reasoning
		holistic thinking in AEC projects can improve their cooperative attitudes and mentalities.
Industry	Changes in business model to unite extrinsic motivation between professionals-firms and firm-firm in the whole building lifecycle.	Practitioners are extrinsically motivated by their firms and their firms are driven by profits. The benefits of digitalisation are more evident from the operations and maintenance phase, however, in current practice teams do not attain profit from it. If firms receive profit from other parts of the lifecycle (e.g., operations and maintenance savings) it would unite the motives and risk perception of client and firms. The example of sharing risk and reward to unite extrinsic motivation is evident from IPD or Alliance contracts which if genuinely followed, has brought about improved collaboration. Additionally, it would allow clients to trust firms' intentions in using innovation for value in the later phases.
Industry	Changes in business model to unite individual practitioner extrinsic and intrinsic motivation by changing firm's focus to building lifecycle not as a service in the project lifecycle.	The practitioner is put under pressure by their firm to generate profits. From above, if the firm is generating profit depending on the digitalisation success, then the unity of individual extrinsic and intrinsic motivation can be improved.

The HMC-AEC can be used in the following ways to create impact.

For the researcher; this research shows that studying a factor in a level of the HMC-AEC should consider the effects of the other levels' effect on that factor; this interdependence and complexity needs to be addressed in future methodology development. The HMC-AEC presents a valid starting point to visualise multi-level interdependency to bring a holistic view with respect to reality; the researcher does not necessarily need to go through the entire sense-making process to create an overall view of phenomena. Consideration of multi-level perspectives can ensure that research outcome is applicable to practice. For example, performance metrics are becoming increasingly important. The HMC-AEC and perspective here give a realistic account that can be utilised to develop social scientific performance metrics.

For practitioners; e.g., in implementation of digital tools, use of contracts and procurement, information delivery strategies, human centred aspects require careful consideration. The HMC-AEC can assist in visualizing the dependencies of project driven changes on people and be used to seek out challenges and barriers. The HMC-AEC gives the practitioner a tool to think holistically and judge risks that are easily left out because of the human

intangibility bias. The HMC-AEC can also be utilised as a point of departure in developing a human factors integration framework such as in the defence industry.

For educators; the HMC-AEC can be used as a tool for students to reflect on cases of project success/failure and connect multi-level factors to gain a holistic understanding as done in medical education. This would develop the students' ability to judge intangible risks and develop their ability to think and learn reflectively; this way of learning is lacking in practitioners and education programmes according to experts.

9.3 Part 2: Research Reflection

Sections 9.3.1 and 9.3.2 provide the observations made from reflection on the study, results and methodology. Section 9.3.3 is a personal reflection considering the effects between the research process and the researcher.

9.3.1 Observations from Reflection of Study and Results

To get high performing inter-organisational teams, the results suggest that the social climate is essential to develop; social interaction is a psychological and social experience to an individual about technical ventures to generate and exchange information. From the results, it is evident that technical aspects did not emerge in an isolated fashion rather more technical aspects were expected e.g., interoperability and standardisation. It was common consensus that technological difficulties are not solely a technical problem but one that involves people. The technical barriers appeared to be symptomatic of rooted social and psychological challenges alleviated by new processes and technology; commitment and adapting to change is human centred.

Why are people the centre? Compared to 2D work methods, BIM needs a paradigmatic change. When using 2D documents, expectations are clear from established historical practice; information is produced in different ways but presented in standard forms. With BIM, these expectations require setting in a collaborative process depending on the capability of each team; the way the information is generated is important in ensuring the information can be used further in the supply chain. For example, the way the models are structured needs to meet expectations of the stakeholders' needs later in the lifecycle of the project and building. Understanding and acting on these expectations depends on the social and psychological factors.

Since digitalisation brings changes in the way people work, interact socially, and measure their own value; this is not only an industrial change but one that affects people personally and socially. Changes in the way people operate in the industry means changing e.g., their routines and job description, asking them to learn new ways and change previous norms that they have felt psychological comfort. The current causes for concern in some UK companies for the impact of digitalisation on social well-being of employees. The need for increased awareness of the need for corporate social responsibility is valid and relevant – it is important to act on any negative effects on well-being from changes in information delivery.

It is observed that inefficiency partly comes from fragmented views of the building lifecycle; partly because teams are only gaining profit from the parts their firm is contracted to be involved in. Keeping in mind, project participants being paid by their firms and not the projects. For example, in relation to the poorly met FM requirements or in traditionally run construction projects, the poor BIMM structure passed on from design teams to contractor(s) makes the existing information difficult to modify and develop. Furthermore, simplification of contracts and payments by splitting roles and output goes against the interdependent nature of the product in construction projects; this interdependent nature becomes more evident as increases in

digitalisation are implemented. Traditionally, teams are not extrinsically motivated to collaborate, rather, greater transparency from collaboration makes them more susceptible to changes which can bring penalties; clashing intrinsic motivation of using new technology and extrinsic motivation to protect their firms' interests.

It was surprising that many teams focus on managing design changes rather than avoiding the changes by collaborating efficiently and openly. In Study 1, the PM firm was one of Finland's fastest growing innovators, the firm's focus was to avoid changes rather than manage them using e.g., interactive meetings early in the design process led by project facilitators; challenging the normative practices of traditional meetings. The tendency to focus on managing design changes is also enabled by software capability making it easier to make these changes. Ironically, this can result in inefficiency at the project level; false security to work fragmented/alone and manage changes, just as the traditional management contracts simplify and facilitate. With the complexity of design increasing and the need for better perspectives from other parts of the lifecycle (e.g., contractors, facility managers) increased focus on avoiding changes rather than managing changes is required. Although simplifying the delivery of information fragmenting design and construction phases from one another has benefits (e.g., easier administration) using complex tools needs to be accompanied with understanding of the needs of other parts of the lifecycle and the commitment to the project vision of how it can be achieved. This is certainly not a technical incompetency, it has shown to be a combination of process, individual or cultural incompetence.

From the understanding gained it is possible to argue that the construction and real estate industries globally are awaiting disruption. Although, a sudden disruption is unlikely because it depends on different stakeholders involved at different parts of the lifecycle. The shift is from a project lifecycle (design and construction) focus to a building lifecycle (design, construct and operate) focus; the advantages of digitalisation are more evident in the later parts of the building lifecycle and performance enhancement is systemic just like the nature of significant project innovation. This shows that there are fundamental shifts needed in the industry, currently, the industry is too fragmented to make the transformational shift in focus from a project lifecycle to a building lifecycle, which would match a typical client's perspective. Although, this is not to state that this industrial evolution of information delivery will not happen, rather, the current slow nature of changes in practice will not change without radical changes in business models and social aspects (also suggested by Downes, 2009). The changes in social and business aspects are already happening. The use of Alliance contracting, and the increased awareness of corporate social responsibility are examples of this; changes in the business model can facilitate social change, although, people will appear hesitant to step out of the long-standing cultural norms (what they are comfortable with doing appears less risky).

The views of practitioners varied significantly although not radically, showing the high complexity of the central topic; collaboration. Generalisability of these views were circumvented

by gaining an overall understanding of the data; all data transcription, analysis and collection was conducted by the researcher. This understanding enabled by sense-making was used to develop the structure to a multi-level model (HMC-AEC), which is used to show the nature of interdependency and hierarchy between factors. It also provides an explanation of complex phenomena and to show the dependence on Human Psychology and Culture (HP&C). The HP&C is fundamental and cannot be changed easily, therefore adapting the other parts of the model to suit HP&C is needed to drive fundamental changes. Just as Volker (2019) explains, the actual driving forces in industrial practice require understanding. Although this was the predominant aim, the research does not claim that it completely understands collaboration, however, contributes to structure the understanding of multi-level interdependent phenomena; giving the researcher an understanding of human phenomena dependency in practice.

9.3.2 Observations and Reflection on the Method

The responses in interviews and focus groups varied based on personal interest, personality, and experience; however, all had similar interactions between human and technical aspects. When probed for a reason, the human aspects were derived. The unique and variable nature of perspectives from project level participants reported in this thesis seems to validate the adoption of a semi-structured qualitative approach, which naturally evolved with respect to the researcher's understanding. A symptom of this evolution in methodology is in the research questions developing from a way to measure collaboration to holistic understanding of the concept.

Existing literature is predominantly positivist or quantitative in the CM domain; oversimplified complex phenomena lack coverage of interdependencies identified in this thesis. A trend can be seen between this thesis and that of Barrett (2018) which focused on design teams. Both of which studied collaboration; both show the unsuitability of quantitative approaches with the current state of knowledge by shifting to qualitative approaches. Indeed, significantly higher value was driven from explorative qualitative data. Although, this is not to state that quantitative approaches will not be suitable to develop understanding in this topic, rather that the knowledge in the domain has not developed enough, knowledge appears to be disconnected and fragmented.

The recruitment of participants was done with the assistance of gatekeepers who were interested in the presented research from the European Conference on Product and Process Modelling (ECPPM) conference in 2016. These gatekeepers assisted in selecting participants, supporting the researcher during the data collection and therefore impacted the methodological design implicitly. Advantages of using gatekeepers was in assisting the researcher to understand the participants' background before the interview or focus group. As sense-making was involved in the session to probe and develop questions, this information contributed to the researcher's understanding and therefore is believed to have made the session efficient. Furthermore, since both gatekeepers belonged to the local culture, this gave the researcher understanding of local cultural expectations.

In planning the stages of research, for the exploratory study the intention was to get a real time project perspective. However, this was challenging to arrange and the number of participants engaging in project level collaboration was limiting the statistical validity of the quantitative part. The main study was then designed to focus on experiences of collaboration from practitioners operating in the design and construction part of the building lifecycle.

The methodology evolved with the constraints from the gatekeeper's ability to arrange involvement with industry. For example, the Study 1 gatekeeper was involved in research and development in a Project Management (PM) firm in Finland and therefore facilitated interviews with staff involved in managing design and construction. On the other hand, the Study 2 gatekeeper was an academic with strong links to companies in Norway who arranged focus groups with six firms.

The expert interviews were needed as a result of the researcher's reflection on the analysis of factors. They were held to ensure the researcher's understanding of the data was practical and to ground the understanding and analysis back to the reality that strategists face. The motivation behind interviews held with experts assumed that they have a holistic view of practice.

The limitations to qualitative studies are predominantly in the difficulty to generalise because of the variety of views of phenomena. However, this is also a strength because with a variety of views, the researcher gained a richer perspective. Because there is no suitable way to statistically validate the claims made in this thesis, the findings need to be taken as hypothesis for further research. Another limitation was in the distance between the study subjects and the researcher as the primary study was held in Finland and Norway making access to participants more difficult. Although, the participants were easily contactable when verification of meaning was required.

9.3.3 Personal Reflection

The reflection below presents the personal thoughts, evolution of understanding and views in the researcher's development and their interaction with the research. As is usual, this section is written in the first person.

9.3.3.1 Goals and Applications

The exploratory study was developed based on the need for metrics made evident during the review of literature. During this process, the review of literature shaped my perceptions of Project level collaboration(PLC) and the selection of this topic. Growing up in a family that runs a medium sized construction contracting business resulted in reflections on conflicts between designers and contractors that would often hamper the contractor's profitability. At an early age, I was directly exposed to the challenges in the industry such as change orders and the competitive nature of the tender process.

The review of literature in turn affected the methodological design. From the exploratory study, a positive aspect was that the qualitative study gave me a better understanding of the

complexity of collaboration; an eye-opener of the difference in perspectives from different professions. In retrospect, I did not expect this study to be a exploratory study, I expected it to lead to an improved design of a metric. However, the complexity of PLC was evident from the qualitative data which made me feel that neither did a practitioner or literature nor myself really understood all the aspects that affect collaborative working; discovering the complexity and interdependence resulted in moments of insight and confusion which motivated my intellectual curiosity. Why? I think it is because the complexity cannot be managed in working mental memory and when it comes to structuring a model, it is challenging to describe. Turning an initially apparent chaotic dataset through sense-making and thematic analysis was challenging but interesting; my mind would zoom in and out repeatedly to find a way of structuring the understanding.

One of the eye-openers was the effect of culture and human factors evident from the exploratory study; the more contractually fragmented project was less collaborative than the less contractually fragmented one - I wanted to understand collaboration in practice, therefore opted for an explorative qualitative approach which sat in opposition to my engineering instinct from my background as a civil/structural engineer. As time passed, I became more comfortable with this non-numerical approach.

Spending time interviewing practitioners made me appreciate the complexity of PLC. I came to appreciate the differences in perspectives between disciplines, types of firms and those inflicted by the culture set out between the teams. Although I thought that PLC could be measured with the knowledge I gained from literature, it became evident that finding a way to facilitate holistic understanding was needed first. This was inevitable when trying to generalise the qualitative results and this required the mention of many pre-existing conditions. My aims and hopes for this thesis are to give researchers and practitioners a holistic vision of the nature of PLC complexity and to show the value of the HP&C factors. Much can be achieved with self-driven reflection, which means that educating practitioners to have this type of routine in their daily practice can be of immeasurable personal, business and social value.

9.3.3.2 Methods and Process

At the start of this research, I felt confident that a metric would be developed. However, the complexity drove a methodological change. Even after this methodological shift, the variation in qualitative results was much more than expected; this prevented the direct practice-based utility that I had intended to provide. Often the data showed aspects that practitioners, educators and researchers need to be 'mindful' of. The variety of factors and the semi-structured nature of the data brought about a few reliably predictable patterns of behaviour. With the understanding brought forward from the rich data collected and analysed in this thesis, I believed that it could one day be used to develop a metric. By adopting a holistic vision, I believed that social scientific metric development can be more precise. I would suggest the use of mixed methods in other

AEC industry companies as the next step in this research to increase reliability and turn understanding into a tool directly useful for practice.

During the multiple data collection periods, I also became aware of how the research process shaped my experiences and understanding. By engaging with practitioners, I asked them to consciously reflect on practice surrounding PLC in ways that they might not have otherwise done. Several interviewees showed high levels of interest, enjoyed the interview process and appeared to have a therapeutic effect on them; it was both a sense-making process of complex phenomena for the interviewee and myself. In the main study, in the beginning, I asked the interviewees/participants to tell me whether PLC could be improved or not and what they would improve. This was a good decision as often emotionally driven responses came across (e.g.,, in a focus group with a contractor, there was anger toward higher level management and the lack of support in digitalisation given to middle management). The emergence of the emotional response in the beginning gave me an indication of the kind of personalities that were present. Some had to be probed to express, others expressed their views willingly and needed to be moderated depending on their personality.

The ethical practice (information sheet and signing the consent form) presented me with a useful method of explaining the project and assuring the participants of the confidential nature of data handling. This enabled participants to put across sensitive information sometimes against competitors or even their own higher-level management in giving supporting examples of a challenge to PLC.

My role in the data collection process was difficult; I had to extract as much detail and perspective from the participants within an allocated time and also had to interpret their response (sense-making) to understand whether I had enough information to avoid misinterpretation during the analysis stage. Since English was not the first language of all interviewees and focus group participants (Studies 1 and 2), particular care had to be taken to ensure that my interpretation was similar to that of the participant's. The soft data from casual conversation about their role and company in the beginning of the session gave me a good understanding of the lingual capability and made the participants gain comfort with me. This data was also recorded to help me remember the session and understand the participant.

9.3.3.3 Data Interpretation

It is important to appreciate that the analysis presented in this thesis is that of my own subjective interpretation of qualitative data. For example, emotion was evident; e.g., from the public client representatives' tone (in Norway), the lack of change of typical firms was frustrating members of the focus group. Tone, eye contact, expressions were not easy to convey via transcription, yet it shaped my understanding of the text. Voice recordings of the sessions shaped my understanding of the participants' viewpoint.

Conducting sessions was often demanding due the semi-structured nature of interviews/focus groups. I had to build a conducive atmosphere for participants to reliably express their experiences. This involved understanding their roles, personality and their use of language to avoid misinterpretation of data and enhance clarity of perspective. Furthermore, at the core of the session an intense sense-making process was occurring cognitively in my mind to understand, probe and confirm the view put across by the participant(s).

I feel that my perspective of the research process has changed over the course of this study. I now have a more realistic view in how research goals are translated into achievements with experience in the challenges and compromises made in the process. Conducting research with industry practitioners in other countries presented its own challenges; it was necessary to slightly adjust the research process to accommodate barriers e.g., timescale and budget of the data collection trips, availability of practitioners. I am aware that practitioners simply do not have enough time to spend extensive periods of time talking to researchers like myself as their time is valuable. The breadth and depth of the analysis reported in this thesis and the style adopted is an attempt to show the rich insight that can be achieved through this type of research.

9.4 Research Limitations

The exploratory study used a more positivist mixed methods approach to test a metric developed from literature and researcher's experience/intuition. The limitations of the exploratory study are presented in Section 3.6. Although trends could be seen in some constructs e.g., agreeableness a trait of personality, the qualitative part of the study showed a higher level of complexity that required understanding, making the positivist approach redundant with the current state of knowledge regarding collaborating teams at the project level.

The research contained in this thesis is exploratory in data collection and explanatory by being inductive in the model development. The research contributes to understanding the complexity and influences of collaborative behaviour at the project level. However, aspects beyond the focus surrounding the meso level were unable to be explored and explained to high detail because of the limited timeframe of this research.

The analysis of experiences of AEC practitioners aimed to understand the interdependencies of collaboration by the use of individual semi-structured interviews in Study 1 and focus groups in Study 2. The differences in methodology brought better internal validation allowing more reliable convergence from two different perspectives, however, the approach also brought about differences in limitations. In Study 1, the semi-structured approach of individual interviews was both time consuming and required significant mental effort; the researcher had to actively understand the personality and perspective of each participant to comprehend and probe for appropriate examples and perspectives. On the other hand, in Study 2, in focus groups this was not a challenge as the role of the researcher was to manage the discussion in terms of time, scope and understanding. The semi-structured approach in both focus groups and individual

interviews brought difficulty in analysis, where themes and codes consistently changed and adapted; with more structured approach comes easily structured coding.

Breen (2006) suggests the ideal number in a focus group session is 4 to 6 participants. Study 2 utilised focus groups; originally, at least 4 participants were recruited from each firm. However, at the time of data collection, only one focus group had 4 participants, the others had 2 or 3 participants. On the other hand, regarding theoretical saturation, Breen (2006) suggests a total of 10 to 12 participants for a qualitative study; Study 1 had 18 participants and Study 2 had 16 participants. This means that Studies 1 and 2exceeded the recommendations to achiever theoretical saturation in terms of total participant numbers. However, in Study 2, most independent focus groups' participant numbers did not meet the recommended values.

Confirmation bias is interpreting evidence in ways that are partial to existing beliefs, expectations or current hypothesis (Nickerson, 1998). To avoid confirmation bias, open questions were used to reduce the effect of confirmation bias (Powell et al., 2012) as shown in Appendices E and F. Confirming the researcher's hypothesis was avoided as it would affect the response from participant(s). Rather, by starting the session by asking participant(s) to define collaboration and asking, 'what contributes to a positive collaborative environment?'; the researcher allows the perspective of the participant to be put forward with minimal influence. However, the researcher's expression and tone in response unavoidably influences the participant's responses. Additionally, for the main study, probes were keywords to avoid the confirmation bias; the questions in the researcher guide were only used to guide the participant if necessary. In the future, research like this should utilise multiple researchers to compare findings between them and therefore, increase reliability (Powell et al., 2012). Within the scope of this PhD research project, this was not viable.

Ambiguity is inherent in human language and represents a limitation of qualitative research (Atieno, 2009). The researcher took approaches both within the session and during analysis to ensure that the interpreted meaning was representative of the intended meaning. During the session, participants were asked for an example, or more explanation if the intended meaning was not clear. Participants and gatekeepers assisted in the process of clarification during analysis to ensure meanings and interpretations were consistent.

One of the challenges in ensuring the interpreted meaning and intended meaning matched; the location of Studies 1 and 2 were not first language English speaking countries, meaning that definitions of key terms needed to be clarified and additional time given to interviews and discussions.

The lingual capability of project level practitioners (Studies 1 and 2) in relation to human psychology and cultural aspects also made the analysis challenging. Participants did not have the knowledge of psychology and linguistic capability to describe the root causes of symptoms they were describing but were still able to convey the message by using examples bringing the researcher's sense-making and inference into practice. This became more evident when

interviewing experts who were able to express views direct to the root causes. Within the five experts, the two experts with a background in psychology or human factors had lingual ability in describing the root causes using terminology not usually used by practitioners in the industry.

Gatekeeper related limitations exist in the methodology. The possibility that the Study 1 gatekeeper may have selected participants in a biased manner, furthermore, the firm was known to be one of the best firms in the industry for project management. To avoid this, there were several meetings with the gatekeeper to determine the expectations of researcher and firm, one of the needs was that there should be adequate coverage of participants involved in both design and production part of the PL. The Study 2 gatekeeper brought in firms interested in research, which may not be representative of the average firm in the industry.

Qualitative data collection lacks statistical validity in a cohesive quantitative manner. This was not the purpose; the purpose was to holistically understand collaborative practice. However, 'soft' triangulation was utilised to help the researcher interpret the contents of the data. This soft triangulation gave narratives and analysis structure by allowing focus on central aspects about which interdependent factors are discussed.

Due to the subjective nature of the methodology, more requiring the sense-making process, biases from the researchers understanding cannot be avoided. For this reason, Section 9.3 is a reflection with the primary aim to indicate the researcher's personal views about the method, research process, HMC-AEC and results.

9.5 Recommendations for Future Research

The holistic perspective put across in this research brings possible hypothesis for future research. Most importantly, it is suggested that researchers understand that for technological adoption to be successful, it requires relevant social, business and political change (Downes, 2009) where the receptiveness of people to changes in practice need careful consideration. The following are suggested:

- Based on the model developed, the knowledge of factors affecting collaborative practice can be treated as point of departure for metric development. Since the project teams are selected early in the project, most of whom have previously not interacted; assessing their compatibility can be useful to practice.
- A tool can be developed to assess the collaborative nature of projects. This could be used by researchers to compare project characteristics with project progress, assuming that the project's social climate changes depending on the progress.
- The factors under the HP&C category of the HMC-AEC require further understanding. To make impactful changes to project delivery means making suitable changes with respect to the capability of HP&C factors, and current practice. Researchers studying such factors need to recognize that for it to have practical value, they have to be open to influences to and from the micro, meso, macro and other HP&C factors. The factors in

reality are very sensitive, missed factors can bring oversimplification and therefore, loss of practical value.

- The influence of technological changes on mental health and social well-being of practitioners require investigation in the CM domain. The lens of Corporate Social Responsibility (CSR) can be used to make practical suggestions to industry. The structure of the HMC-AEC can be utilised to make sense of the psychological and social influences on practitioners. For example the multi-level influence from personal characteristics from personality traits.
- Practitioners require the ability to think holistically in practice. The model's ability to provide a holistic view of practice to students needs to be further explored. The most suitable pedagogic strategies need to be researched for CM practice. Although this brings long-term change, if a practitioner understands the interdependent nature of the building solution and industry practice; it is predicted that they would be more cooperative towards inter-team challenges. In this thesis, the biopsychosocial approach from health care and the HFI policy from defence industry are used to exemplify this need.
- As described above, changes in pedagogy take a long time to affect practice. However, for the short-term, training mechanisms require developing to help practitioners develop their ability to think holistically and consider the bigger picture influenced by their involvement. As shown in Figure 55, these factors are difficult to perceive without assistance.
- The need for further exploration on innovating the business model of the industry. This research shows the need for initiative to extrinsically motivate teams with value from the building lifecycle to enable holistic thinking which suits building lifecycle digitalisation and client motivation. With the rise of interest of blockchain technologies with regards to litigation, more dynamic contracts may enable disruptive change to the business model that suits digitalisation. There is need to ensure that teams operating in the project level are incentivised to think about the entire building lifecycle. Until there are extrinsic gains (e.g., profit) to project level teams from the operations and maintenance phase, perspectives between the client and the project level teams will be no different than traditional delivery. There is a need to reduce the psychological distance between clients and teams by uniting the extrinsic motivations.
- There is a need for research to develop more complex and dynamic contracts which better suit digitalisation and collaboration; businesses need to have united extrinsic motivation by getting involved in building lifecycle digitalisation as a whole rather than fragmenting the project lifecycle from it. This would involve collaboration with financial and contract litigation experts to investigate business model and contract innovation shift from project to building lifecycle. It is predicted that if the risks in the building lifecycle

are split amongst all stakeholders, it would motivate them similarly and therefore, positively influencing digitalisation implementation. The way to split the risks is difficult to estimate, however, actuarial science can be applied as done in the insurance industry. The solution should consider the capacity of the various firms to ensure that the portion of their stake going to longer investment would not affect the company's stability in the short-term.

- Changes in research and practice-based models: The IDDS model requires adapting to the knowledge gained from interpretive studies such as this one; there is a need to add a foundational level that include the Human Psychology and Culture aspect discovered in this study. Without the addition, the dependency of changes in process and technology on HP&C is not explicit, therefore, not recognised as significant.

9.6 Concluding Remarks – Repositioning Technology and Interoperating People

The thesis took an unusual approach to adopting a holistic perspective of reality. In doing so, it has raised some fundamental questions about AEC industry practice. If the technology is well developed, why is it not showing the expected improvements? Resulting in the overall research question; *What could enable better project level collaboration and efficient implementation of digitalisation in the AEC industry?*

Technology provides tools that people use to create a solution to a problem. In the AEC industry, the people come from different backgrounds and have their own expectations of the way the solution should look. This is complex because of a number of factors, some of which are presented in the HMC-AEC.

The technology has been available for more than a decade; however, it is not as successfully used as expected. The key finding in this thesis is that focus needs to be on interoperating people in relation to supporting technological adoption. The expectations and needs of teams need to be developed with trust and openness. If people are not willing to operate openly and trustfully in an AEC project, they will not use the tools to make information management more efficient; the inefficiency from lacking unity is evident in another part of the building lifecycle.

The industry needs to evolve to allow for responsibility beyond contractually defined involvement across the building lifecycle; meeting the needs of stakeholders later in the process is vital. Symptoms of an evolution are evident from increased use of IPD, alliance, partnering and long-term contractual frameworks that spread the project risk. Drivers for more efficient technological adoption need to begin with drivers for improved inter-team collaborative practice – from the Study 1 PM firm, the project managers put trust and openness at the forefront of practice making them one of the most successful PM companies in the Finnish AEC industry.

This approach enables better exchange between teams considering the needs of other stakeholders and the client.

The positive value of innovative information management is mostly felt by the asset owner in the operations and maintenance phase of an asset which is approximately three times the cost of construction. In other words, the benefits of the project lifecycle labour in using innovation are not always felt by them. People are not incentivised well to use the technology in a specific way by seeing the impact on the asset.

This thesis brings together factors to consider when developing a trusting and open interorganisational team. Using this knowledge gained from the practitioner's experience of collaboration, psychological theories in decision-making are applied, motivational aspects defragmented and reflections on improving digitalisation by collaboration provided.

The suggestions of the Egan and Latham reports are still valid and very similar to the ones found by this thesis raising questions of whether the industry can substantially improve without significant changes in delivery methods and contractual models, therefore affecting practitioners' motivation. Without these changes that would facilitate required social and behavioural changes will make technological improvements more challenging across organisational boundaries.

This thesis contributes with increased understanding by identifying and exploring most relevant knowledge holistically. This enabled the application of psychological theories in decision-making, overviews of the defragmented motivational aspects and reflection to improve digitalisation using inter-professional collaboration. Methods and principles used in this academic research of the human aspects of practice in conjunction with ongoing technological advances can contribute to more efficient implementation of digital solutions creating greater impact.

The research is also timely, the outcomes can align with the 'Capability Framework and Research Agenda for a Digital Built Britain' published by CDBB in July 2019, which calls for:

> *'new research into frameworks and business models… to provide a robust portfolio of next steps to build the capabilities needed for digital built Britain' (Neely et al., 2019, p. 31).*

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APPENDIX A – GLOSSARY

Key Word or Theme	Definition
Accountability	the condition of being held responsible
Alliance contracts	a shared risk and reward contract commonly used in Finland
Attitudes	a way of thinking that affect show decisions are made
Belief	the indication of acceptance that something is true or exists
Building Information Management	management of a virtual digitally constructed models of a building
Building Information Model	a virtual digitally constructed models of a building (Eastman et al., 2011)
Business Model	the manner in which a company generates revenue
Change Management	approaches to develop changes in how organisations operate both within themselves and with others
Client Decision-making	the way the client decides
Client Emotion	the client's instinctive or intuitive feeling derived from circumstance and relationships with others
Client Finance	the strength and way of managing finance of a client
Client Involvement	the day to day involvement of the client in the inter-operation of teams
Client Knowledge	the client's understanding of the industry
Client Organisational Culture	the client organisation's visions, values, norms, systems, symbols, language, assumptions, beliefs and habits (Needle, 2010)
Client Requirements	the needs of the customer
Collective Ownership	group ownership for mutual benefit
Co-location	physically located together
Comfort (psychological)	psychological ease
Competition	the activity of striving to gain/win and achieve superiority over similar firms
Contracts	a binding legal arrangement enforceable by law
Data Exchange	the transfer of information between teams and individuals which can be either in an informal or formal capacity
Education	the way knowledge is acquired
End-user	the final user of a building
Experience	an individual's exposure to the industry
Extrinsic motivation	external motivation
Facilities Management	managing an organisation/individual's building or property
Financial	relating to finance and the way it is managed
Fragmentation (industrial)	a measure of the number of players typically used to acquire a building/product/service
Frame of Reference	Set of criteria that are used to describe phenomena
Goals	the expectations of the project

Key Word or Theme	Definition
Heuristics	mental shortcuts people utilise based on little information that reduces the cognitive burden associated with decision-making (Shah and Oppenheimer, 2008)
Hierarchy	indicated by the number of levels in a firm's organisation structure
Holistic Understanding	the understanding of the whole system that affects how work is done
Human Resources	the process of hiring/developing employees to deploy them as needed in a project
Incremental Change	a change that affects only some associate people, processes and tools within an organisation
Informal Information	tacit non-technical information
Information Delivery	the creation, exchange and definition of information in achieving a BIM
Information Latency	the delay that information has between stimulus and response (Murray, 2010)
Inter-organisation	between 2 or more organisations
Intra-organisation	within one organisation
Intrinsic motivation	internal motivation
IPD	a shared risk and reward contract
Leadership	the action of leading a group of teams driven by a common goal
Liability	the manner in which teams lose profitability
Local Culture	the norms of the culture in the industry based on a geographical location
Local Policy	laws in society that affect how operation of projects are carried out
Micro Change Management	managing the changes to the design solution
Motivation	needs, desires, wants or drives within individuals or groups
Openness	lack of restriction to express an individual or team's view
Organisational Culture	the organisation's visions, values, norms, systems, symbols, language, assumptions, beliefs and habits (Needle, 2010)
Personality	individual differences in characteristics to do with thinking, feeling and behaving (Major et al., 2000)
Planning	the action(s) of preparing and scoping a solution
Price-based Selection	selection of products or services based on lowest price
Process Management	initiatives taken to manage the way that information is created or exchanged
Procurement	the way that services or products are obtained
Professional Organisation	an independent industry organisation that sets the standards for operation
Quality	the standard of a service/product
Respect	a way of treating or thinking about another individual or group
Rewards	recognition of effort or achievement typically in the form of finance
Stakeholder Accountability	the responsibility of everyone that is affected by the project

Key Word or Theme	Definition
Systemic Change	a change that affects all people, processes or tools in a project/industry
Tacit Knowledge	knowledge that is difficult to manage as it is embedded in human beings, it is from the experience of individuals that are used to express evaluation, attitudes, points of view, commitments and motivation (Pathirage et al., 2007)
Team Selection	the process of choosing a firm to acquire a product or service from
Technical Competency	the technical understanding and capability of an individual or group
Technical information	recordable and non-tacit information
Trust	a belief of the reliability or ability of another individual or team
Verstas	a big room meeting, involving interaction and problem solving between all key project personnel

APPENDIX B – EXAMPLE PARTICIPANT INFORMATION AND CONSENT FORM

Participant Information Sheet - Interview
Title of Study: Perception Based Collaboration Metric Development Finland
Researcher: Sujesh F. Sujan
Date: 24/11/17
You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. Please also feel free to discuss this with your friends and relatives if you wish. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to.
Thank you for reading this.
What is the purpose of this study?
The purpose of this study is to develop a method for researchers or professionals in industry to enable them to envisage the level of collaboration in a team environment. The study aims to do so by departing from projects in the AEC industry.
Why have I been chosen to take part?
You are a professional working in an industry classified as a project based inter-organisational network; the AEC industry. You have been selected as a prospective interviewee as the project you work at is the subject to a study done on teamwork collaboration and risk perception. The information collected will help put the results of the survey into perspective.
Do I have to take part?
Participation in this study is voluntary and you are free to withdraw from it at any time without explanation.
What will happen if I take part?
All personal data is to be kept anonymous
The interview will involve questions about:
- Collaboration and teamwork in a particular project
- Procurement strategies utilised
- Common difficulties faced when collaborating with other design disciplines
- The level of fragmentation and integration of the project

Expenses/Payments
As the research does not take too long to complete and does not require any travel, there will be no payments made to participants in this study.
Are there any risks in taking part?
There are no risks or disadvantages of taking part in this study as all the information will be kept safely in the university database
Are there any benefits in taking part?
There are no immediate benefits in participating in this study. However, the respondent could learn to see how important it is to be willing to collaborate in the AEC industry.
What if I am unhappy or if there is a problem?
If you are unhappy, or if there is a problem, please feel free to let us know by contacting Sujesh F. Sujan (sgssujan@student.liverpool.ac.uk) who will try to help. Alternatively, you may contact the supervisors for this research whose contact details are at the bottom of this document.
Will my participation be kept confidential?
Data will be collected and stored anonymously for use by the researcher for this research project. All research data will be securely deleted after the dissertation is formally approved. All the information will be secure in the University of Liverpool's local server. No information will be released publicly with project name or interviewee personal information.
What will happen with the results of this study?

The results from this study will be collected and compared between projects to draw findings and further develop method. To make sure that the respondent cannot be traced, no personal information such as names would be collected, interviewee position in firm will be taken (as there may be need for further clarifications) however anonymised in data analysis and publication. Any published information will be completely anonymised including the project name.

What will happen if I want to stop taking part?

For interviews, data can be withdrawn up to 30 days after the interview is held, after which it will be anonymised.

Who can I contact if I have further questions?

Student Researcher:

Name: Sujesh F. Sujan
Work Address: The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone: 0044 7807993553
Work Email: sgssujan@student.liverpool.ac.uk

Supervisors:

Name: Dr. Steve Jones
Work Address: School of Engineering, The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone: 0044 151 794 5228
Work Email: Stephen.Jones@liverpool.ac.uk

Name: Prof. Arto Kiviniemi
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Work Email: A.Kiviniemi@liverpool.ac.uk

Name: Dr. Jacqueline Wheatcroft
Work Address: Institute of Psychology, Health and Society, University of Liverpool
Waterhouse Building, Block B, Brownlow Street, Liverpool L69 3GL, United Kingdom
Work Telephone: 0044151 795 0513
Work Email: J.M.Wheatcroft@liverpool.ac.uk

Committee on Research Ethics

PARTICIPANT CONSENT FORM

Title of Research Project: Perception Based Collaboration Metric Development

Researcher: Sujesh F. Sujan

Please initial box

1. I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected. In addition, should I not wish to answer any particular question or questions, I am free to decline. ☐

2. I confirm that I have read and have understood the information sheet dated 1/07/16 for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily ☐

3. I agree to take part in the above study ☐

4. I understand that once I have participated in the interview, and once all survey and interviews are conducted, due to the anonymity of the data, I will not be able to modify my answers or remove myself from the study. ☐

_____	_____	_____
Participant Name	Date	Signature
_____	_____	_____
Name of Person taking consent	Date	Signature
_____	_____	_____
Researcher	Date	Signature

Student Researcher:

Name	Sujesh F. Sujan
Work Address	The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone	07807993553
Work Email	sgssujan@student.liverpool.ac.uk

Supervisors:

Name	Dr. Steve Jones
Work Address	School of Engineering, The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone	0151 794 5228
Work Email	Stephen.Jones@liverpool.ac.uk

Name	Prof. Arto Kiviniemi
Work Address	The Liverpool School of Architecture, University of Liverpool, Leverhulme Building, Liverpool L69 7ZN, United Kingdom
Work Telephone	0151 794 3575
Work Email	A.Kiviniemi@liverpool.ac.uk

Name	Dr. Jacqueline Wheatcroft
Work Address	Institute of Psychology, Health and Society, University of Liverpool Waterhouse Building, Block B, Brownlow Street, Liverpool L69 3GL, United Kingdom
Work Telephone	0151 795 0513
Work Email	J.M.Wheatcroft@liverpool.ac.uk

APPENDIX C – EXPLORATORY STUDY RESEARCHER INTERVIEW GUIDE

Introduction – How are you involved in the project? What do you do on a day to day basis?

1. In your opinion, out of 10, from your experience, what would you consider the project being in terms of collaboration between firms? How would you rate the best project you have been a part of?
2. What do you think can be improved in this project?
3. What is your personal viewpoint in how digital tools can help collaboration?
4. What were some of the constraints in collaboration associated with the project?
5. Could firms be open about their mistakes? Especially when it affects everyone's work?
6. Has your firm worked with the lead designer previously?
7. What were the difficulties in exchanging information?
8. Do you think people were a bigger constraint to exchanging information rather than the technology?
9. Do you think that firms agreed on who the lead designer was?
10. Can you think of some examples of scenarios that made you annoyed with other firms' teams? How were they dealt with by the leader?
11. In your opinion, what keeps teams from communicating efficiently?
12. Was the lead designer involved in all the major disciplinary decisions?
13. What was the most collaborative project you have worked on in your career? How was it set up? (Procurement strategy, contract, existing relationships etc.)
14. If you realised that there was a fundamental error in your team's design, what would be the procedure of informing the other teams?
15. How would this affect you with respect to the contract utilised?
16. Imagine a scenario where all the design teams were in the same firm, do you think this 'vertically integrated' environment would make the design process more efficient?

APPENDIX D – EXPLORATORY STUDY QUANTITATIVE INSTRUMENT

Perception Based Collaboration Metric Development

Participant Information Sheet – Explanation of Research Rationale and Confirmation of Anonymity and Confidentiality

Researcher: Sujesh F. Sujan
Date: 03/04/17

You are being invited to participate in a research study. Before you decide whether to participate, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and feel free to ask us if you would like more information or if there is anything that you do not understand. Please also feel free to discuss this with your friends and relatives if you wish. We would like to stress that you do not have to accept this invitation and should only agree to take part if you want to. Thank you for reading this.

What is the purpose of this study?
The purpose of this study is to develop a method for researchers or professionals in industry to enable them to envisage the level of collaboration in a team environment. The study aims to do so by departing from projects in the construction industry.

Why have I been chosen to take part?
You are a professional working in an industry classified as a project based inter-organisational network; the construction industry. You have been selected as a prospective respondent as the project you work at is the subject to a study done on teamwork collaboration and risk perception.

Do I have to take part?
Participation in this study is voluntary and you are free to withdraw from it at any time without explanation.

What will happen if I take part?
All personal data is to be kept anonymous.The research survey will form four parts. Firstly, there will be some questions relating to the project and your role in the project.

The second part will involve some open ended questions asking you to provide example scenarios of risks that can affect the entire project's progress.

The third section involves two subsections. One subsection presents risk based scenarios (examples) and allows you to judge their probability. The other half of the third section allows you to judge the scenario's severity (i.e how this scenario affects your firm and your firm's business objectives?)

The final section involves presenting 6 viewpoints of the teamwork environment, you are asked to judge the level of agreement with respect to the way the project is managed and run.

Expenses/Payments
As the research does not take too long to complete and does not require any travel, there will be no payments made to participants in this study.

Are there any risks in taking part?
There are no risks or disadvantages of taking part in this study as all the information will be secure in the University of Liverpool's select survey service database.

Are there any benefits in taking part?
There are no immediate benefits in participating in this study.

What if I am unhappy or if there is a problem?
If you are unhappy, or if there is a problem, please feel free to let us know by contacting Sujesh F. Sujan (sgssujan@student.liverpool.ac.uk) and I will try to help. Alternatively, you may contact the supervisors for this research whose contact details are at the bottom of the page.

Will my participation be kept confidential?
Data will be collected and stored anonymously for use by the researcher for this research project. All research data will be securely deleted after the dissertation is formally approved. All the information will be secure in the University of Liverpool's select survey service database. No information will be released publically with project name or respondent personal information.

What will happen with the results of this study?
The results from this study will be collected and compared between projects to draw findings and further develop method. To make sure that the respondent cannot be traced, no personal information such as names would be collected. Furthermore any published information will be completely anonymised including the project name.

What will happen if I want to stop taking part?
Due to the anonymity of the research, results may only be removed from the study up until the point of anonymity which is when the survey is completed. After that it is not possible to identify your answers and thus not remove them from the material.

Who can I contact if I have further questions?

Student Researcher:
Name: Sujesh F. Sujan
Work Address: The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone: 07807993553
Work Email: sgssujan@student.liverpool.ac.uk

Supervisors:
Name: Dr. Steve Jones
Work Address: School of Engineering, The Quadrangle, Brownlow Hill L69 3GH, Liverpool, L69 3BX
Work Telephone: 0151 794 5228
Work Email:Stephen.Jones@liverpool.ac.uk

Name: Prof. Arto Kiviniemi
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Work Telephone: 0151 794 3575
Work Email: A.Kiviniemi@liverpool.ac.uk

Name: Dr. Jacqueline Wheatcroft
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Work Telephone: 0151 795 0513
Work Email: J.M.Wheatcroft@liverpool.ac.uk

Perception Based Collaboration Metric Development

Consent

1. Do you agree with the following? (Unfortunately if you do not agree with the following, you will not be able to take part in the survey)

	Yes	No
I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason, without my rights being affected. In addition, should I not wish to answer any particular question or questions, I am free to leave them unanswered.	○	○
I confirm that I have read and have understood the information provided for the above study. I have had the opportunity to consider the information, ask questions and have had the opportunity to consider the information before proceeding.	○	○
I understand that once I have submitted my answers to the survey, due to the anonymity of the data, I will not be able to modify my answers or remove myself from the study.	○	○
By proceeding, I agree to take part in the above study	○	○

Perception Based Collaboration Metric Development

Introduction

New model based innovations such as Building Information Modelling (BIM) require a highly collaborative environment to maximize efficiency. This study is done in order to develop a method by which scholars can gain perspective as to how much stakeholders are collaborating in a construction project.The four parts of this survey comprise of:

Part 1: General Information of Respondent
Part 2: Perception of Teamwork Environment
Part 3: Perception of Systemic risks
Part 4: Individual Perception

Perception Based Collaboration Metric Development

Part 1: General Information of Respondent

2. What is your age?
   - ○ 18-25 years old
   - ○ 26-35 years old
   - ○ 36-45 years old
   - ○ > 45 years old
   - ○ Prefer not to say

3. How long have you been working at your current firm?
   - ○ 0 to 1 year
   - ○ 1 to 2 years
   - ○ 2 to 5 years
   - ○ 5 to 10 years
   - ○ More than 10 years

4. What is your gender?
   - ○ Female
   - ○ Male
   - ○ Prefer not to say

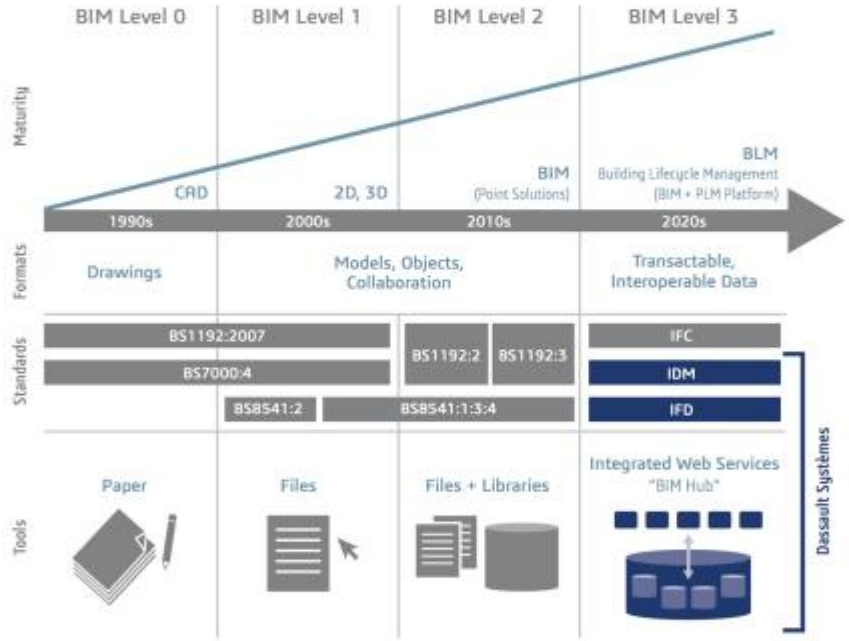
5. Please select the most relevant to your firm's invovement in this project:
   - ☐ Design (Architectural)
   - ☐ Quantity Survey or Cost Consultant
   - ☐ Design (Structural)
   - ☐ Design (Civil)
   - ☐ Project Management
   - ☐ Design (Electrical)
   - ☐ Design (Mechanical)
   - ☐ Other, please specify

6. How long have you worked as part of a design team in the construction industry?
   - ○ 0 to 5 years
   - ○ 6 to 10 years
   - ○ 11 to 15 years
   - ○ 16 to 20 years

- ○ >20 years

7. What is your most preferred form of procurement?
   - ☐ DB: Design and build contract.
   - ☐ CD: Standard form with contractors design.
   - ☐ CE: Constructing excellence contract.
   - ☐ CM: Construction management contract.
   - ☐ IFC: Intermediate form of building contract.
   - ☐ MC: Management contract.
   - ☐ MTC: Measured term contract.
   - ☐ PCC: Prime cost building contract.
   - ☐ MP: Major project construction contract
   - ☐ SBC: Standard form of building contract.
   - ☐ Other, please specify

8.



The BIM Maturity Model by Mark Bew and Mervyn Richards adapted to reflect BLM's relationship to Level 3.

Referring to the diagram above, in your opinion, what level of digital technology do all the design teams in the Materials Innovation Factory project work at?

- ○ Level 0
- ○ Level 1
- ○ Level 2
- ○ Level 3

9. Are you in direct contact with a member of another firm's team?
   - ○ Yes
   - ○ No

Perception Based Collaboration Metric Development

Part 2: Perception of Teamwork Environment

10. Below are statements to do with the teamwork environment. How much do you agree with each statement with respect to how teams worked together on the **Materials Innovation Factory** project?

Likert scale:
Select **1** if you **disagree very strongly** or the statement is definitely false.
Select **2** if you **disagree strongly** or the statement is false.
Select **3** if you **disagree** or the statement is mostly false.
Select **4** if you are **neutral** on the statement, if you cannot decide, or if the statement is about equally true and false.
Select **5** if you **agree** or the statement is mostly true.
Select **6** if you **agree strongly** or the statement is true.
Select **7** if you **agree very strongly** or the statement is definitely true.

	1	2	3	4	5	6	7
I feel that the project has a clear and defined lead designer							
It is important that the lead designer arranges work in ways that helps each disciplinary group reach their goals							
The lead designer rarely influences what the other disciplines do							
I trust that the lead designer will ensure the interest of all disciplines involved in design							
We never solve defined problems in collaboration with all disciplines							
There are rarely collaboration problems in doing inter-disciplinary work							
In most inter-disciplinary work, we never agree about priorities							
Professionals from different disciplines are often frustrated with each other							

I get relevant feedback from other disciplines about my teams contributions

Exchange of information between disciplines is always a problem

There is always good communication between disciplines

Professionals from other disciplines are bad at exchanging information with each other about how they work

I feel that I can get help and support from other disciplines

I find that professionals from other disciplines are not willing to listen to me if I have problems

I find that my teams view is appreciated by other disciplinary groups

I never find that other disciplinary teams understand what my firm's team is trying to express or report

I feel that I am not able to make significant decisions without consulting the lead designer

I can be open about an error that affects other design firm's work as soon as it is recognised

Perception Based Collaboration Metric Development

Part 3: Perception of Systemic Risk

11. Below are examples of risks. How probable/impactful do you think the following scenarios are?

Likert scale: **(probability – how likely is the risk to happen/occur?)**

Enter **0** if you **cannot decide**
Enter **1** if you think it's **impossible** to occur
Enter **2** if you think it's **improbable** to occur
Enter **3** if you are **neutral** on the statement
Enter **4** if you think it's **probable** to occur
Enter **5** if you think it will **definite**ly occur

Likert scale: **(Impact or severity - how much is the risk going to impact the cost to the client/cost to your firm/project schedule?)**

Enter **0** if you **cannot decide**
Enter **1** if you think it will have **no impact**
Enter **2** if you think it will have **a minor impact**
Enter **3** if you are **neutral** on the statement
Enter **4** if you think it will **moderately impact**
Enter **5** if you think it will **majorly impact**

	Probability	Impact on Client Cost	Impact on Firm's Cost	Impact on Project Schedule
Further ground investigations missed out a key feature				
The Client decides to abandon the project after significant work is done				
A new project manager is introduced in the project when detailed design is underway				
The procurement strategy and contracts used restrict collaboration between disciplines				
The client does not understand the need to bring in relevant teams at an earlier stage				
The design phase is based on incomplete information				

12. Please note down similar examples of risks that could affect all designers: (please also put down a probability and impact rating as above)

Part 4 of the QI is withheld as it is copyrighted.

APPENDIX E – STUDY 1 RESEARCHER INTERVIEW GUIDE

Introduction:

What I expect to get out of this research is?

- An understanding of the various factors that affect collaboration in the Finnish AEC industry
- To validate the findings from previous studies

Research Questions:

- What could enable better project level collaboration and efficient implementation of digitalisation in the AEC industry?

1. Introduction by researcher: explaining the research and what we need (5 minutes)
2. Introduction from participant: name, profession and experience etc. (10 minutes)
3. Open discussion about collaboration: researcher asks the participant about what they feel is the most important factor in ensuring people collaborate positively. (15 minutes)
4. Discussion of factors brought forward by previous studies: the researcher uses the following topics as a guide. The questions below are only used if needed (30 minutes)
    a. Trust
        a. What does trust mean to you?
        b. Why is it important to trust the other team members?
        c. How important is trust?
    b. Relationships
        a. If you have an existing relationship with a team? Does it help collaboration? Why?
        b. How can teams develop relationships if they have never worked with each other before? What are the strategies currently used? What do you think can be done to facilitate relationship development?
        c. How does personality affect the relationship?
        d. Can people generally be open about the problems? Examples?
    c. Client
        a. How can the client affect team collaboration?
        b. How does the clients knowledge affect team collaboration?
        c. How does the decision-making ability of a client affect collaboration?
        d. How does working with the public client differ from working with a private client? Which one do you prefer working with and why?
        e. Do clients know enough and have enough experience to make major decisions?
        f. Does the client know how to operate a BIMM?
        g. Do you feel that the requirements from a client can affect team motivation and therefore collaboration?
        h. The client that tries to 'save every penny'
    d. Leadership
        a. In your opinion, what would be the best way to lead a project? Who is in the position to be the leader? The architect? Or a neutral team?
        b. What attitudes should a leader have?

        c. Should everything decided go through the leader? Even small decisions?
    e. Contracts
        a. Do you think that teams work to provide the best for the client? If not, why not?
        b. How are teams motivated to provide the best for the client?
        c. Are teams rewarded for good performance? Is this important?
        d. Team's accountability to the project leader, is this important?
        e. Shared understanding of the needs of the client?
        f. Have contracts evolved with BIM? What are the most common contracts? Which one do you prefer?
    f. Team selection
        a. What is considered when teams are selected?
        b. Why is it easier to work with people?
    g. Mentality
        a. Does it feel like the people in the AEC industry are working in the same way as they were 20 years ago? Why does it feel that way? Or Why not?
        b. Are there needs for these changes?
        c. Can you see any changes in the mentality with changes in technology such as BIM?
        d. How can these changes be encouraged or be driven?
        e. Do you feel that people in the AEC industry are only concerned with what they need to do and not others in a 'holistic' manner?
        f. Historically, the industry has evolved from being able to make changes slowly and then to making changes quickly, does it feel as if we make changes too quickly these days?
    h. Policies
        a. When the permission to build is needed, do teams just do enough for the approval? Do you think they need to do more to give the client best value?
        b. How do local policies affect team collaboration?
5. Is there anything we haven't spoken about that you feel that may affect positive team collaboration?

APPENDIX F – STUDY 2 RESEARCHER FOCUS GROUP GUIDE

Introduction:

What I expect to get out of this research is?

- An understanding of the various factors that affect collaboration in the Norwegian AEC industry
- To validate the findings from previous studies

Research Questions:

- What could enable better project level collaboration and efficient implementation of digitalisation in the AEC industry?

1. Introduction by researcher: explaining the research and what we need (5 minutes)
2. Introduction by each participant: name, profession and experience etc. (10 minutes)
3. Open discussion about collaboration: researcher asks the participants about what they feel is the most important factor in ensuring people collaborate positively. (15 minutes)
4. Discussion of factors brought forward by previous studies: the researcher uses the following topics to guide discussions (30 minutes) The questions below are only used if needed
    i. Trust
        a. What does trust mean to you?
        b. Why is it important to trust the other team members?
        c. How important is trust?
    j. Relationships
        a. If you have an existing relationship with a team? Does it help collaboration? Why?
        b. How can teams develop relationships if they have never worked with each other before? What are the strategies currently used? What do you think can be done to facilitate relationship development?
        c. How does personality affect the relationship?
        d. Can people generally be open about the problems? Examples?
    k. Client
        a. How can the client affect team collaboration?
        b. How does the clients knowledge affect team collaboration?
        c. How does the decision-making ability of a client affect collaboration?
        d. How does working with the public client differ from working with a private client? Which one do you prefer working with and why?
        e. Do clients know enough and have enough experience to make major decisions?
        f. Does the client know how to operate a BIMM?
        g. Do you feel that the requirements from a client can affect team motivation and therefore collaboration?
        h. The client that tries to 'save every penny'
    l. Leadership
        a. In your opinion, what would be the best way to lead a project? Who is in the position to be the leader? The architect? Or a neutral team?
        b. What attitudes should a leader have?

        c. Should everything have decided go through the leader? Even small decisions?
    m. Contracts
        a. Do you think that teams work to provide the best for the client? If not, why not?
        b. How are teams motivated to provide the best for the client?
        c. Are teams rewarded for good performance? Is this important?
        d. Team's accountability to the project leader, is this important?
        e. Shared understanding of the needs of the client?
        f. Have contracts evolved with BIM? What are the most common contracts? Which one do you prefer?
    n. Team selection
        a. What is considered when teams are selected?
        b. Why is it easier to work with some people?
    o. Mentality
        a. Does it feel like the people in the AEC industry are working in the same way as they were 20 years ago? Why does it feel that way? Or Why not?
        b. Are there needs for these changes?
        c. Can you see any changes in the mentality with changes in technology such as BIM?
        d. How can these changes be encouraged or be driven?
        e. Do you feel that people in the AEC industry are only concerned with what they need to do and not others in a 'holistic' manner?
        f. Historically, the industry has evolved from being able to make changes slowly and then to making changes quickly, does it feel as if we make changes too quickly these days?
    p. Policies
        a. When the permission to build is needed, do teams just do enough for the approval? Do you think they need to do more to give the client best value?
        b. How do local policies affect team collaboration?
5. Is there anything we haven't spoken about that you feel that may affect positive team collaboration?

APPENDIX G – EXPLORATORY STUDY QUANTITATIVE RESULTS

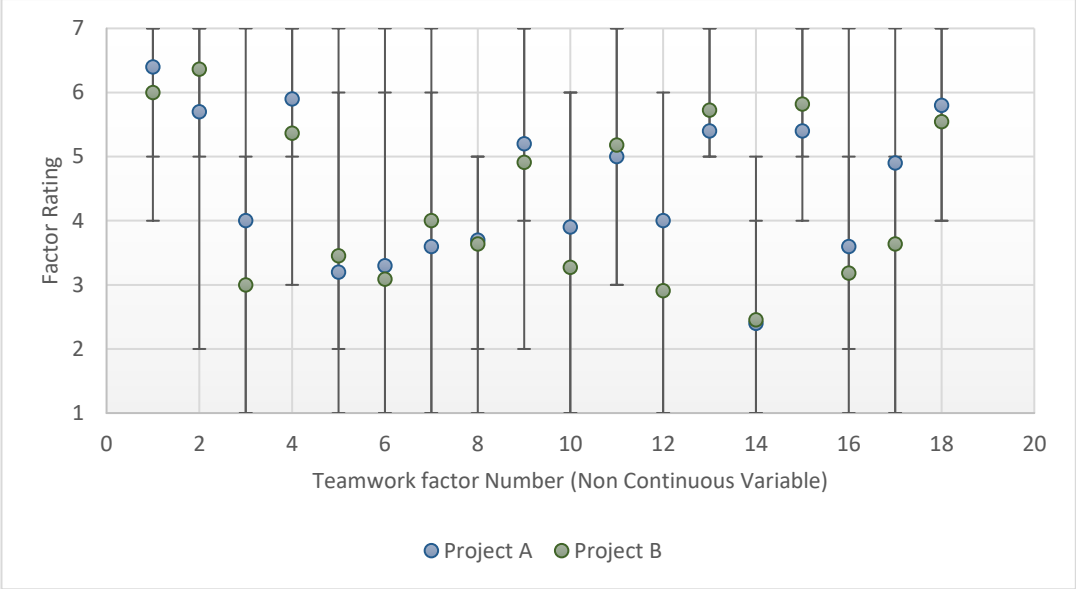
Teamwork Results (Part 2)

	Teamwork Factor
T1	I feel that the project has a clear and defined lead designer
T2	It is important that the lead designer arranges work in ways that helps each disciplinary group reach their goals
T3	The lead designer rarely influences what the other disciplines do
T4	I trust that the lead designer will ensure the interest of all disciplines involved in design
T5	We never solve defined problems in collaboration with all disciplines
T6	There are rarely collaboration problems in doing inter-disciplinary work
T7	In most inter-disciplinary work, we never agree about priorities
T8	Professionals from different disciplines are often frustrated with each other
T9	I get relevant feedback from other disciplines about my teams' contributions
T10	Exchange of information between disciplines is always a problem
T11	There is always good communication between disciplines
T12	Professionals from other disciplines are bad at exchanging information with each other about how they work
T13	I feel that I can get help and support from other disciplines
T14	I find that professionals from other disciplines are not willing to listen to me if I have problems
T15	I find that my teams view is appreciated by other disciplinary groups
T16	I never find that other disciplinary teams understand what my firm's team is trying to express or report
T17	I feel that I am not able to make significant decisions without consulting the lead designer
T18	I can be open about an error that affects other design firm's work as soon as it is recognised

Project A	Mean	Median	Variance	Std. Deviation	Minimum	Maximum
T1	6.40	7.00	1.156	1.075	4	7
T2	5.70	6.00	2.456	1.567	2	7
T3	4.00	4.00	2.889	1.700	1	7
T4	5.90	6.00	0.767	0.876	5	7
T5	3.20	3.00	4.844	2.201	1	7
T6	3.30	3.00	5.344	2.312	1	7
T7	3.60	4.50	4.711	2.171	1	7
T8	3.70	4.00	2.456	1.567	1	5
T9	5.20	5.00	1.067	1.033	4	7
T10	3.90	4.00	2.322	1.524	1	6

Project A	Mean	Median	Variance	Std. Deviation	Minimum	Maximum
T11	5.00	5.00	1.333	1.155	3	7
T12	4.00	4.00	2.000	1.414	1	6
T13	5.40	5.00	0.489	0.699	5	7
T14	2.40	2.50	1.378	1.174	1	4
T15	5.40	5.00	1.156	1.075	4	7
T16	3.60	3.50	2.267	1.506	1	7
T17	4.90	5.00	4.322	2.079	1	7
T18	5.80	6.00	1.067	1.033	4	7

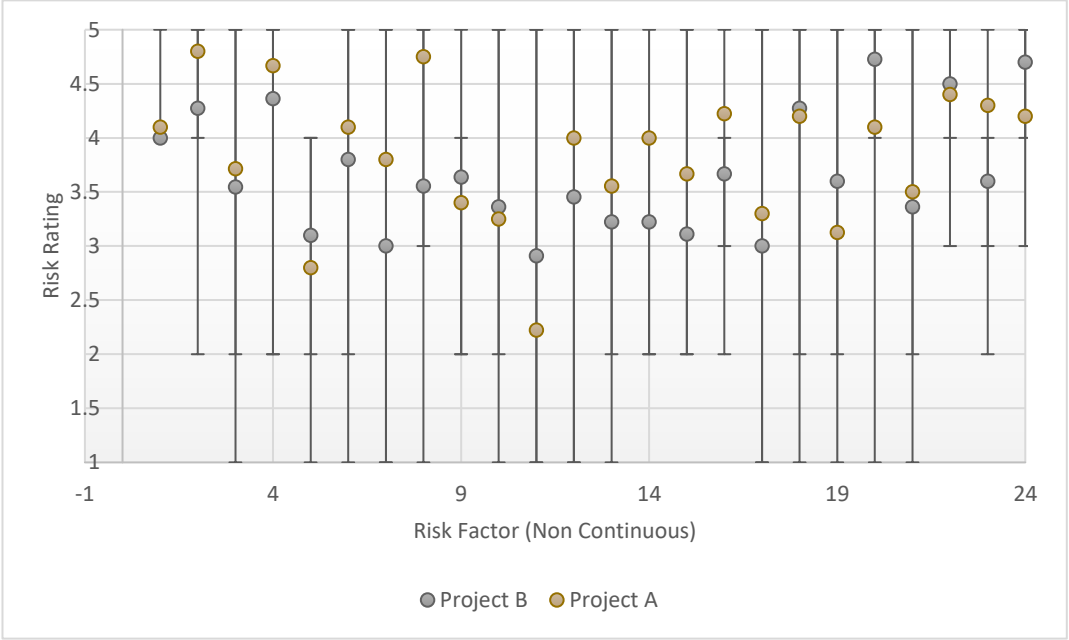
Project B	Mean	Median	Std. Deviation	Variance	Minimum	Maximum
T1	6.00	6.00	1.000	1.000	5	7
T2	6.36	6.00	0.674	0.455	5	7
T3	3.00	3.00	1.483	2.200	1	5
T4	5.36	6.00	1.286	1.655	3	7
T5	3.45	3.00	1.508	2.273	2	6
T6	3.09	3.00	1.375	1.891	1	6
T7	4.00	4.00	1.414	2.000	1	6
T8	3.64	3.00	1.206	1.455	2	5
T9	4.91	5.00	1.446	2.091	2	7
T10	3.27	3.00	1.489	2.218	1	6
T11	5.18	5.00	1.168	1.364	3	7
T12	2.91	3.00	1.044	1.091	1	4
T13	5.73	5.00	0.905	0.818	5	7
T14	2.45	2.00	1.128	1.273	1	5
T15	5.82	6.00	0.751	0.564	5	7
T16	3.18	3.00	1.079	1.164	2	5
T17	3.64	3.00	1.433	2.055	1	5
T18	5.55	5.00	1.128	1.273	4	7



Systemic Risk Results (Part 3)

	Judgement Criteria	Risk
1	Probability	Further ground investigations missed out a key feature;
2	Probability	The Client decides to abandon the project after significant work is done;
3	Probability	A new project manager is introduced in the project when detailed design is underway
4	Probability	The procurement strategy and contracts used restrict collaboration between disciplines
5	Probability	The client does not understand the need to bring in relevant teams at an earlier stage
6	Probability	The design phase is based on incomplete information;
7	Impact on Client Cost	Further ground investigations missed out a key feature;
8	Impact on Client Cost	The Client decides to abandon the project after significant work is done;
9	Impact on Client Cost	A new project manager is introduced in the project when detailed design is underway
10	Impact on Client Cost	The procurement strategy and contracts used restrict collaboration between disciplines
11	Impact on Client Cost	The client does not understand the need to bring in relevant teams at an earlier stage
12	Impact on Client Cost	The design phase is based on incomplete information;
13	Impact on Firm	Further ground investigations missed out a key feature;
14	Impact on Firm	The Client decides to abandon the project after significant work is done;

	Judgement Criteria	Risk
15	Impact on Firm	A new project manager is introduced in the project when detailed design is underway
16	Impact on Firm	The procurement strategy and contracts used restrict collaboration between disciplines
17	Impact on Firm	The client does not understand the need to bring in relevant teams at an earlier stage
18	Impact on Firm	The design phase is based on incomplete information;
19	Impact on Schedule	Further ground investigations missed out a key feature;
20	Impact on Schedule	The Client decides to abandon the project after significant work is done;
21	Impact on Schedule	A new project manager is introduced in the project when detailed design is underway
22	Impact on Schedule	The procurement strategy and contracts used restrict collaboration between disciplines
23	Impact on Schedule	The client does not understand the need to bring in relevant teams at an earlier stage
24	Impact on Schedule	The design phase is based on incomplete information;



Number	Project A	Mean	Maximum	Minimum	Max Variance	Min Variance
1	**SP1**	4.1	5.0	4.0	0.9	0.1
2	**SC1**	4.8	5.0	4.0	0.2	0.8
3	**SF1**	3.7	5.0	2.0	1.3	1.7

Number	Project A	Mean	Maximum	Minimum	Max Variance	Min Variance
4	**SS1**	4.7	5.0	2.0	0.3	2.7
5	**SP2**	2.8	4.0	1.0	1.2	1.8
6	**SC2**	4.1	5.0	1.0	0.9	3.1
7	**SF2**	3.8	5.0	1.0	1.2	2.8
8	**SS2**	4.8	5.0	3.0	0.3	1.8
9	**SP3**	3.4	4.0	2.0	0.6	1.4
10	**SC3**	3.3	5.0	1.0	1.8	2.3
11	**SF3**	2.2	5.0	1.0	2.8	1.2
12	**SS3**	4.0	5.0	1.0	1.0	3.0
13	**SP4**	3.6	5.0	1.0	1.4	2.6
14	**SC4**	4.0	5.0	2.0	1.0	2.0
15	**SF4**	3.7	5.0	2.0	1.3	1.7
16	**SS4**	4.2	5.0	2.0	0.8	2.2
17	**SP5**	3.3	5.0	1.0	1.7	2.3
18	**SC5**	4.2	5.0	1.0	0.8	3.2
19	**SF5**	3.1	5.0	1.0	1.9	2.1
20	**SS5**	4.1	5.0	1.0	0.9	3.1
21	**SP6**	3.5	5.0	2.0	1.5	1.5
22	**SC6**	4.4	5.0	3.0	0.6	1.4
23	**SF6**	4.3	5.0	3.0	0.7	1.3
24	**SS6**	4.2	5.0	3.0	0.8	1.2

Number	Project B	Mean	Maximum	Minimum	Max Variance	Min Variance
1	**SP1**	4.0	4.0	4.0	0.0	0.0
2	**SC1**	4.3	5.0	2.0	0.7	2.3
3	**SF1**	3.5	5.0	1.0	1.5	2.5
4	**SS1**	4.4	5.0	2.0	0.6	2.4
5	**SP2**	3.1	4.0	2.0	0.9	1.1
6	**SC2**	3.8	5.0	2.0	1.2	1.8
7	**SF2**	3.0	5.0	1.0	2.0	2.0
8	**SS2**	3.6	5.0	1.0	1.4	2.6
9	**SP3**	3.6	5.0	2.0	1.4	1.6
10	**SC3**	3.4	5.0	2.0	1.6	1.4
11	**SF3**	2.9	5.0	1.0	2.1	1.9
12	**SS3**	3.5	5.0	1.0	1.5	2.5
13	**SP4**	3.2	5.0	2.0	1.8	1.2
14	**SC4**	3.2	4.0	2.0	0.8	1.2
15	**SF4**	3.1	5.0	2.0	1.9	1.1
16	**SS4**	3.7	4.0	3.0	0.3	0.7
17	**SP5**	3.0	5.0	1.0	2.0	2.0
18	**SC5**	4.3	5.0	2.0	0.7	2.3
19	**SF5**	3.6	5.0	2.0	1.4	1.6
20	**SS5**	4.7	5.0	4.0	0.3	0.7

Number	Project B	Mean	Maximum	Minimum	Max Variance	Min Variance
21	**SP6**	3.4	5.0	1.0	1.6	2.4
22	**SC6**	4.5	5.0	4.0	0.5	0.5
23	**SF6**	3.6	4.0	2.0	0.4	1.6
24	**SS6**	4.7	5.0	4.0	0.3	0.7

Personality (Part 4) Results

	Discipline	Agreeableness	Conscientiousness	Extraversion	Neuroticism	Openness to Experience
Project A	**QS**	2.00	3.08	2.33	1.42	2.83
Project A	**SE**	2.67	3.25	2.92	1.17	2.83
Project A	**Civil**	2.58	2.67	2.17	1.00	2.33
Project A	**PM**	2.17	3.00	2.58	1.25	2.33
Project A	**Arch**	2.75	3.00	2.75	1.58	2.83
Project A	**PM**	2.67	2.50	2.50	0.25	2.25
Project A	**SE**	2.17	2.75	2.75	1.92	2.58
Project A/B	**Elec mec h**	2.83	3.42	2.83	1.25	3.33
Project B	**QS**	3.00	3.33	2.75	0.92	2.17
Project B	**Mec h**	2.75	2.75	2.25	2.25	1.25
Project B	**CLI ENT PM**	3.08	2.00	2.83	2.25	3.08
Project B	**QS**	2.58	2.42	2.50	2.17	2.33
Project B	**CLI ENT (Ele c)**	2.75	3.17	2.25	0.83	1.67
Project B	**CLI ENT (Arc h)**	2.67	3.50	2.92	1.33	2.50
Project B	**Arch**	2.92	3.58	3.33	1.17	2.92
Project B	**SE**	2.64	2.50	3.08	1.45	2.92
Project B	**SE**	2.50	3.50	2.17	1.17	3.00
Project B	**SE/ Civil**	2.58	3.17	3.08	1.00	2.25
Project B	**clien t**	2.92	2.42	1.33	1.83	3.50
Project A/B	**Elec**	2.83	3.42	2.83	1.25	3.33

Project B Average	2.77	2.98	2.61	1.47	2.58
Project A Average	2.48	2.96	2.60	1.23	2.67

APPENDIX H – EXPERT INTERVIEW QUESTIONS

Introduction:

- Ethics:
    - Voice recorded
    - No data will be shared with your name – Anonymised
    - Consent Needs to be signed

Background:

- What is your current role? Experience? Designer/Consultant vs Contractor
- Have you worked in design or mainly in production? Where lies your expertise
- **This study focuses on the design and construction phase, however, if there are points from other parts of the lifecycle that affect a point you are raising with the design/production, please continue with it.**
- The aim of the project is to understand the factors that affect project level collaboration in design/construction, so I will present you with some questions that are raised based on the findings of my research.
- An expert interview is required to use your perception as an expert to locate gaps in the data e.g., contextual differences, to find researcher bias, reaffirm or disconfirm findings and the methodology.
- Therefore, to avoid affecting your perception (bias) by telling you about the themes and methodology, I will first start with the questions that emerged from the results, then we can have a more open discussion about the methodology and the results, is that okay?
- What is collaboration to you and why is it important? What is a highly collaborative environment the product of? What is the most important factor in your opinion? (might be hard to choose but what was the first thing you think of when I say 'problems in collaborating') Do you feel it's more of a technical issue or a human issue?

Let's move to the questions...

1. How does client driven risk affect project level decision-making?
    a. How do firms deal with these risks?
    b. What do you think about the effect of client knowledge of the construction process in creating an environment to suit positive collaboration?
    c. How important Is the involvement of the client with teams to you? Why?
    d. What do you feel about the need for clients to trust the teams working on the project especially the leader? What are the consequences of mistrust?
    e. How can the client's organisational culture affect the way that they make important project decisions?
    f. What is the most common risk that clients bring to the project?
    g. What is the attitude of the typical client in the public industry?
    h. As compared to the private client, which client is more decisive?
2. What can you tell me about attitudes that arise from 'subcontracting to hedge risk'?
    a. 'it's your problem not mine' mentality of firms in the Sub-Contractors, hedging the risk attitude, what effect does this have?
    b. At the project level, how are risks interdependent? how does this relate to the attitude?
    c. Can the attitude arising from hedging risk be related to the commonly documented blame culture?

3. What does change management mean to you? How does change management affect collaborating teams?
    a. What do you think about understanding the 'end to end' process of practitioners in design and construction? Do they understand how their work affects the others?
    b. How does differences in technical competency affect project level collaboration?
    c. What do you think about the business model and how it's based on 'Short term thinking/success'?
    d. Are changes being made in a small part of the project lifecycle?
4. What do you think of when I say human factor in collaboration?
    a. Trust? Relationships? Are they valued enough? How can they be valued?
    b. What do you think about the process changing at a different pace to how people are used to changing? If agree, why? Comfort?
    c. What is the effect of personality on collaboration?
    d. What is the effect of differences of geographical based cultures on collaboration? What is different between teams from different countries?
5. How does leadership affect collaboration?
    a. What effect does inconsistent leadership have on project teams?
    b. What is the optimal contractual position for a lead team? i.e. should all contracts go through them?
        i. What is important to make the leader positioned that way from the client's perspective?
    c. What can you tell me about client trust with the lead project management team?
6. How does similarities/differences in organisational cultures of teams affect project level collaboration?
    a. Can there be friction between teams because of differences in organisational cultures? Why do you agree/disagree? Example?
        i. If agreed, what is the effect of this with changes driven by CM, digitalisation?
    b. How does organisational hierarchy affect a firms collaborative performance at the project level? i.e. gap between the decision maker and people working.
7. What factors in managing the process of information sharing and delivery come to mind when dealing with collaboration?
    a. What is the effect of being open with processes by using tools/approaches such as VDC?
    b. How important is Lean thinking? What are the ways lean thinking can make collaboration easier?
8. What factors come to mind when associating contracts with collaboration?
    a. What is the effect of the win/lose mentality on collaboration?
    b. Firms are often held liable if targets are not met, is it common to have rewards?
        i. How would high liability-based contract affect people's attitudes?
    c. What do you think about the way information outputs are defined in contracts?
    d. What do you think about the way that data ownership is defined in contracts?
9. What factors come to mind in efficient procurement to incentivise collaboration?
    a. Which stakeholder is the most optimal in selecting teams? Why?
    b. What is the effect of cost driven procurement?

    c. How can the human factor and relationships be considered in procurement?
10. What is the role of education in ensuring professionals can collaborate?
    a. Is it being done well now? Why? Or Why not?
    b. Do education systems encourage holistic thinking?

APPENDIX I – CHAPTER 5 SUPPORTING QUOTATIONS

Section 5.3 Study 1 Supporting Quotations

Section	Factor	Quotation
5.3.2.1.1	The effect of shared risk and reward in contracts	'we have a customer who used Alliance and also the traditional contract but now only wants to use the Alliance contract… people are doing the work together… the contract models are key. The Alliance way makes people open about the accounts and the customer must be able to get involved more. It's all about money, everybody loses or gains, it's much easier to work together. If you lose, I win, then there are no possibilities to do real collaboration' (1, Design to Production Manager, End to End) 'Alliance project contracts seem to force them to think more holistically about the whole project process, to think about what makes the client gain more value…Alliance contract is new, so we need to educate. It's becoming more common, we have successful projects here in Finland…the contract needs more manpower to tender, to make an offer, more cooperation; in a traditional project the clients don't do much they just check but in the Alliance contract they need to be a solid part of the project team…open book accounting, we need to combine the financial systems from the various companies which are not as integrated; combination of business processes' (2, Schedule Manager, End to End)
5.3.2.1.2		'when our company is contracted only for production and if the designs are bad even if it's not our designers, we end up looking bad because we are the ones building. Clients tend to want to control by selecting the designers, then we argue for modifications and extra work and then the client is arguing with the designers' (3, Process management, end to end) 'the designers usually design to what is easiest for them, but when we are involved, we optimise the design for the client. So, it's harder when we are brought in for production only because we have the designs already there and then we have to make changes which is harder to manage' (10, Development Manager, Design) 'When it goes to production it seems that the stiffer the process of design the more likely that there will be more difficulties to do with the design on site. Maybe that doesn't happen so much if we are part of the design team from the beginning but when we aren't part of the design team and we are given completed plans, then it's very difficult because there are several changes' (12, Design Manager, Design) 'If the design is done, then it is much more difficult to make the changes as the designers may have already shifted their focus to other projects. There is not the same kind of

Section	Factor	Quotation
		motivation when the design is complete, when its being done the team is working on it but when it is done, there may only be one person working on it (as well as other projects)' (15, Production Manager, Production) 'The worst problem is when the client has his own contracts with the designers or sub-contractors, this makes us lose our leverage. So, it affects the relationships and we lose our ability to control. The client can even believe that it is our problem but it's because of the contract they have set up. The client gives out the contract because they think it will save them money but usually it might even cost' (15, Production Manager, Production) 'The client is a lot happier when we have the designers and sub-contractors contracted to us. Then it is our responsibility to manage the contracts from end to end and this allows us to make changes as early as possible; was the most collaborative because we controlled the whole process. It's good that there is designing when construction is going on, there's always a view from site about whether something is not realistic or if something can be done better' (15, Production Manager, Production) 'Big difference between the designer and the sub-contractor's way of working, they are paid differently so they are losing differently' (14, Production Manager, Production)
5.3.2.1.3	Team Selection	'The personalities of the people help avoid the problems or can create it. We need the right balance. There are 2 or 3 people that create the atmosphere, where that is lacking, there can be problems. Or when the teams are not winning teams, it is important to get people that think in the same way. The people come from design teams, our company and main contractor…Trust is crucial' (1, Design to Production, End to End) 'When it's not clear who is responsible for a problem, then it is your job to defend our company… Good people in a bad environment can also become bad' (16, Research and Development, End to End) '…people are not able to cooperate with each other, they don't have the tools to interact with one another, they can't think about other people's concerns. On some projects we have not been able to create trust with some designers or clients' (18, Project Manager, Design) 'When a new person comes in: all the designers have their own way to do it, some things are good, but it will be easier if there is the same person to work with. If we have worked with them, then they know how we think openly and the way that we like the processes to be. It's much easier to

Section	Factor	Quotation
		work with them even if their price might be higher' (18, Project manager, Design) '…there are so many things that they are designing that they don't understand its working in real life…they don't see the other side of things only their own. But when we work with them it is changing. They also enrich their own abilities. They are now more open minded, they think that we are working together now not like how they used to think' (18, Project manager, Design) 'How do you select teams…We usually go to people we already know who make the specific thing. Usually we select based on price, it's not that good at all times. We usually ask for bids from 20 companies, usually price-based but sometimes if we have had a good experience then we select the firm again' (13, Production Manager, Production) 'Most of the people still choose by price, use better designers, better solutions. First, they design and then they have to supervise the whole building process' (10, Development Manager, Design) 'In my opinion when we are writing the contract, the cheapest one is not the cheapest one in the grand scheme of things, but it depends on how they are working' (7, Production Manager, Production)
5.3.2.2.1	Leadership difficulties regarding process management	'Controlling the coordination is critical. A way to lock the design, some teams end up doing more than is needed and it is our job to tell them to stop or keep going. People do not enjoy doing the same thing twice, therefore coordination is key. However, this is not as straightforward because the processes can be misunderstood and mean different things, which makes their previous experience in working with us even more important' (18, Project Manager, Design)
5.3.2.2.2	Informal Information	'I think we need to have something on paper of tangible form of information…Many people feel that we can solve problems from talking but it's not just about talking, we have to develop processes to enhance the information so people can get it in a tangible form, which can be stored. Then it also becomes the company's property. If you have information in your head you own it, but the company doesn't own it when you leave' (16, Research and Development, End to End) 'We have had complaints from the clients that there was a change in environment once the design phase is complete, people have moved on and the production phase people get involved' (3, Process Management, End to End)

Section	Factor	Quotation
5.3.2.2.3	Holistic development of process	'Many of the designers do not understand production and production people also don't understand design. If a person hasn't worked on site before there is a difference in perspective. The education system in Finland splits people in terms of production and design. They can learn from experience but the young people who come straight from the universities find it hard. Site people can usually blame the designers. Other companies don't have the link between design and production as well as we have' (15, Production Manager, Production)
5.3.2.3.2	Idealised change	'Sometimes in this day and age, we try to make too many changes too quickly on a particular project…we are trying to handle the changes instead of preventing them and that's the most challenging' (18, Project Manager, Design) 'We have to show them that our way is going to help them otherwise they won't respect us and follow the processes. It is important to understand that they are not machines and that they are doing a good job. We need to motivate and encourage by seeing the big picture, not the little mistakes' (8, Development Manager, End to End)
5.3.2.3.3	Comfort in changing routines	'Both technology and people are keeping the industry from progressing… It's not a straightforward process to digitalise… From technology point of view, construction is complicated, we need more advanced technology. From people point of view, processes haven't been changing as fast as needed by technology, so they are not used to change, if business stays the same for 20-30 years then the people stay the same. People just think that things won't change. People need to advance' (9, Production Manager, Production) 'Typically, younger people are learning the new way quite rapidly and they grasp the concept fairly quickly, however most old people in the industry seem to not be able to do it in the same way' (3, Process Management, End to End)
5.3.2.4.1	Client knowledge and involvement	'…it's in the contract that they need to give us what they need but they can't do it, they don't have enough knowledge about that. They are the big bosses of some offices or investors. It is a problem everywhere that the client does not understand what they need…' (5, Project Manager, Production) 'Some clients want to do the contracts themselves; sometimes the client is not capable of doing things like they are not capable to make decisions, they don't know what they want, even if asked if we can do something. Things can be done correctly in many ways; maybe they don't understand the importance of the issue, or they just don't know about construction projects' (3, Process Management, End to End)

Section	Factor	Quotation
		'The experts of construction are the most difficult for us because they are most set in their ways. Why? Because they are too confident and comfortable from years of experience of not changing that now they don't want to try something new' (18, Project Manager, Design) 'We have professional clients such as with hotel chains or supermarket projects, they are professional and they tell you what they want, no need to think about what they want. They have the standards so it is easy for them and they are losing money so they will cooperate and make decisions efficiently...these are much less risky projects for us' (14, Production Manager, Production) 'We had one site in a university where we have this monthly breakfast with the client and the design team…We talk about how the project is going. We get the information from the client and sub-contractors. These are not formal meetings, they are just to find information and creating the trust…The client on that project was really thinking in a new way, on a regular project the customer thinks that they don't have time for this kind of non-sense, 'We have to work' they want the regular meetings where one person is talking and everybody else is sitting in silence for 3 hours, it is not efficient at all and is not creating the trust between people' (1, Design and Production, End to End) 'Client needs to tell exactly what they want; we try to get the needs… We have to 'go fishing' to figure out what they want' (18, Project Manager, Design)
5.3.2.4.2	Client trust	'Reluctance from clients to use new contract. Some clients want to do the contracts themselves as they feel that maybe they can't trust us as they think we will make more money; sometimes the client is not capable of doing things like they are not capable to make decisions, they don't know what they want, even if asked if we can do something. Things can be done correctly in many ways; maybe they don't understand the importance of the issue, or they just don't know about construction projects' (3, Process Management, End to End) 'When the client decides the contracts with teams outside us, they can make the contract even before we are brought onto the project. The usual problem is that when we go on site, we don't find the designs there on time and we can't do anything about it because the contract between the designer and the client does not involve us'. (15, Production Manager, Production) 'The worst problem is when the client has his own contracts with the designers or sub-contractors, this makes us lose our leverage. So, it affects the relationships and we lose our ability to control. The client can even believe that

Section	Factor	Quotation
		it is our problem but it's because of the contract they have set up. The client gives out the contract because they think it will save them money but usually it might even cost more' (15, Production Manager, Production)
5.3.2.4.3	Client organisational culture	'.. was public client so they have limits like the apartments can only cost 3000…The public have certain rules, we can't collaborate with them without restrictions. Have to understand that they have a role, so they cannot do anything differently, People are scared of breaching the rules the government has' (16, Research and Development, End to End) 'So, you have a private project, private guy can say leave it like that and let's move on to the bigger issues. Public project would not do that if there is a problem even a small one, they cannot just ignore it…private are more business focused. More relaxed in terms of nature. Important to understand that the public sector client thinks different. Private is more about an investment and therefore they are interested in making more money' (16, Research and Development, End to End)
5.3.3.1	Language and geographical industry cultures	'I have worked with some Danish company which went well, they had sub-contractor who were polish who had poor safety culture, Austrian company was more difficult, German was easy, Hungary was horrible, Czech republic was really bad don't know how they got it done and Swedish was easy... up north the companies are working more and more efficient. South and more eastern we go, the more difficult to work with' (4, Production Manager, Production) 'Sub-contractors from other countries, if they have been working here then they know, the Estonians came it was really hard for them to say that there is a problem but now that they are here for a longer time, they know that they have to be open. German people are similar to the Finnish way.' (9, Production Manager, Production)
5.3.3.2.1	Relationships and trust	'I think if you need to know the people better, you can trust them, it's easier to put opinions out and be open' (17, Project Manager, Design) 'If the sub-contractor is not communicating and doing well I have to keep on checking on them and watching them, if I have 100% trust then I will tell them when it needs to be done then I won't check but no trust I have to keep on checking' (9, Production Manager, Production)
5.3.3.2.2	Relationship Development	'If people are in a social situation then they can understand each other more and therefore build the relationships' (14, Production Manager, Production) 'What do you think about when you do that? We have to know each other, what kind of people they are etc. Can I

Section	Factor	Quotation
		just ask him to do it? Or do I need to ask him in a nice way?' (5, Production Manager, Production) 'Building relationships between the sub-contractors can be a way to improve the process so that they can know each other's working habits' (7, Production Manager, Production) 'More face to face interaction between people (especially in the beginning and consistently) is useful as it's hard to lie or hide from someone you know you will meet in the near future' (15, Production Manager, Production) 'New teams must have team days, and this helps a lot…The three months before the project is to mainly build relationships…To create the atmosphere that we are going to do this. The winning teams are made at this period where we build team spirit' (1, Design and Production, End to End)
5.3.3.3	Personality	'Would a personality test be useful? Yes, I think so, because we want people that are easy to work with… site managers prefer open personalities' (12, Design Manager, Design) 'As part of the selection process if we have a personality-based thing then it can help us see who can work well in groups' (7, Production Manager, Production) 'Strong Personality – sometimes if there is a strong person, it's a little bit like trying to balance with them, trying to do what they want and to try and lead the discussion towards what you want. It's difficult to tell them your opinions, either you need facts or some higher people with you to lean on their side' (7, Production Manager, Production)
5.3.3.4	Holistic understanding and thinking	'The designers don't have the knowledge to choose the most optimal solution from the perspective of production. There has been some improvement over the years. It also depends on the design manager's site experience. (15, Production Manager, Production)

Section 5.4 Study 2 Supporting Quotations

Section	Factor	Quotation
5.4.2.1.1	Win-Lose mentality	'the contracts were made years ago, and things were much different and today things are not considered. The paradox is that contracts have been discussed in the industry for a long time and someone is claiming that it is important and some not, why is it not possible to change it? The paradox that you know it's important and covering it up and it's not being changed. How it's so hard to fundamental change…because the contract in itself is an inhibitor of collaboration. Contracts are driving fragmented work and

Section	Factor	Quotation
		I cover my own part and then I hand over something and then it is gone. The contracts are really pushing this mentality' (Consultant) 'if you start off with this is what you need to deliver with this price, then these are the consequences if not, this is given to one party, the only way they can proceed is to make sure that their backs are covered because they are losing money they have to blame' (Professional Organisation) 'Everything is not working with material or time. This is happening with some clients but a very few, if you look at the volumes you could always say that we do things very traditionally. We have some relationships where we are more mature and more value-based work…' (Consultant)
5.4.2.1.2	Contract effect on collaboration	'The design build contracts are more suitable for open dialogue and transparency. I think the design bid build contracts make the client and people act stricter to the contract. Maybe they have nice mood and it's fun to work but the contract is much harder there. It's not open for dialogue. So, when we cooperate with consultants, it's important to get trust so they can be honest and they can do and not can't do regarding to competence, time and everything and you shouldn't misuse it. Design bid build are more formal in its nature so it's less efficient in communication between contractor and owner, so there is less room for making common understanding' (Contractor) 'Why is it that everybody goes back to this traditional contract, why don't they take the risks? I guess that is because of short term thinking. We do some of that in the development part of businesses. Cause we need to operate the buildings too. But it's hard to get other industry players onboard with that? Challenging status quo is hard always and we need to do it as well' (Consultant)
5.4.2.1.3	Business model and innovation	'first meeting with the client, the teams set up common goals for the project, top management set up a vision, 6 common targets; 3 bullet points for each one. Signed a partnering declaration. Client and us first. We made this the Swedish partnering way. In 6 weeks, we will take the vision and declaration to make a team partnering declaration. Then we break it down, day 1 vision, 2 will be to decide what we will do, the contract in this is totally open, just we make a budget together, it's allowed to change and evolve. If it goes over or under it's a 50/50 type of loss or gain. This is really standardised in Swedish project management…We come up with a price in the beginning, but after a few months, we come up with a better price and then we can close it to less collaboration. But the Swedish original way is to be open economically all the way through. Then we need some common targets to follow up, so there

Section	Factor	Quotation
		will be a partnering group who runs this, and we work with collaboration and openness' (Project Management) 'I think that lots of the problems we have with BIM is that especially if we move the design underneath the construction team, is that they deliver the project based on what they see as necessarily to construct the building, they never see the needs that we have at the later stage for example, they don't see maintenance, FM phase, completely ignore even if part of the contract. The problem is that when the project goes to the dead end, we are in the position where we say that we haven't got the required data, needed to run the building properly. So now we try to collect and get through the BIMM by using cobuilder for example, one solution for it. And the end of the project is coming closer and closer. The people here are leaving but we don't get the information on time as we need it as soon as the building begins operation. Then we are stuck' (public client) 'Like where we are engaged as a design manager for the whole project that happens as well. We make more money when we have the whole process' (Consultant) 'Internally you need to show that it is right but externally we can't really show but just show some old models of projects. Internally the first thing they ask is how much money do we earn from using this? That is a problem because it is not short-term success' (Contractor) 'we know very much what is the barriers not only technology, still it has not changed in a way and this is a paradox because following this logic that when you can influence a small part of the value chain the investment will not be gaining any positive outcome, you have to change the business model to get a larger part…From a research point of view, I cannot find scientific evidence that the productivity will increase or the quality will increase and so on, its minor contribution. From what is going on in development, even if you introduce BIM, it will not inflict much change. The cost of the building will not change drastically because this business model is there' (Consultant) 'What can be a weakness is that when you have everything, and you have the design responsibility then the people take it easy and so not following deadlines. However, if it is an external PM then we have to deliver it as there is a form of control, when everything is done internally there is loyalty and you can't go to the client, so you need to manage that situation internally' (Consultant)
5.4.2.1.4	Team selection	'The paradox is that majority of the project is between us and the client. Then we just turn around and most of the supply chain is bought out on the lowest price, no

Section	Factor	Quotation
		collaboration, no incentivised to collaborate. So, we need a combination of the procurement methods to find the best suitable for the project' (Project Management) '…4 variables; Price, construction experience, solution and ability to fulfil the task, the engineering part (CVs, abilities, references)… we put it in as a variables to be evaluated from 0 to 100% whether they have fulfilled it or not is another story. They can be reasonably good in one field and bad at another.' (Public Client)
5.4.2.2.1	Client knowledge and involvement	'I think it's like whether you are inside the gospel or not, those who understand the value of BIM and how it is used, very often in projects they are translating that into paper drawings, we take all the value out of the product and so I think often they don't understand how we operate and what kind of value we are operating with' (Consultant) 'I don't think it's necessarily the unwillingness in the market to deliver to our needs, but it's a lack of knowledge, experience and understanding of what actually we need. If I just take one example of the last prison projects that we had, is that when you go out and make a pump (hot water around the building). What we see from the last project is that it's defined as a general object, we are not able to link all the data towards that object, because we don't know what type of object it is and then we as the client have to go in and correct all of this. We don't demand it simply because we didn't know!' (Public client) 'I think client competency should be more on process because you hire experts for other parts, if you understand the mechanisms and the incentives and the drivers of it, I think it's much more important. BIM is great but it is not everything and BIM community tends to think that BIM will solve everything so we have huge kind of a 2 sided environment where you have technology and BIM on one part and project competence in the other side and these are still too far apart' (Consultant)
5.4.2.2.2	The relationship with the client	'…engineering team is a reimbursable on an hourly contract and the construction is based on a fixed price. The client is defining that they do. They always have to go to the client. Whatever they come up with will come up to us, who are the project leader' (Public Client) 'We have some relationships where we are more mature more value-based work. The manual vs the automatic side, national museum, a public client, they want to enrich the model with coding based on the building catalogue which is a big manual job, we have a federate model with 5 to 700000 objects so with the clients permission we created a script which we can allow the model to enrich itself with the various codes everyday instead of spending weeks

Section	Factor	Quotation
		doing it. We spent a month on it and ran it. This was not incentivised' (Consultant) '…An example from my view is that, there is a project…the clients have engaged external consultants to represent the client, so they have an agenda which they try to push and they are perhaps strong willed and they enforce rather than consult which means that they can pretty much dictate which hits back on us as the consultants, and this brings negativity in the collaboration' (Consultant) 'But we have this new government client that have gotten mandate to get more road for the money. Smaller organisation without the controlling engineers and just D and B contracts, they say that the contractor is the expert, much more trust, different way of running' (Contractor) '…when they have controlling engineers that look over your shoulder all the time, they are always saying no to change. Guess they are like that because its more tough pricing culture, to win a project it's all about money, nothing about quality, its moving towards more understanding of a project…' (Contractor) '…long tradition from the Norwegian road authority, if you are building according to the specifications, then you have the quality in place, so their mentality they think that quality is default because they have the specs… addressing the importance of looking into value. Maybe culture is the problem' (Contractor) 'The client was managing the project very strictly with respect to the fixed price contracts and we got that project because we were the lowest bidder as always the work is more complicated and therefore end up using the budget. Then the group of designers and architects got stuck because they were trying to do as little as they could because the client was not very polite, or he didn't try to promote and create a cooperative environment. The project got too expensive and they had to stop it to get to do the financial assessments that public clients require to do…When it started up again. The business model was then changed, it was no longer a fixed price, they told us to do the work the best that we could, we had to deliver budgets and say if it wasn't enough. The climate for cooperation was totally different. The project manager was also different, he was younger and more into this collaborative model. He was totally different even that was important for collaboration' (Professional Organisation) 'In our company we have 5 qualified BIM advisors but we have 160 projects, from that it's obvious that we cannot do detailed checking, we have to rely on the entrepreneurs or on the organisation set up around engineering part of it but they do a lousy job. Out of the projects over the last 10

Section	Factor	Quotation
		years, we have perhaps one project that we can say it's successful from a BIM deliver point of view' (Public Client)
5.4.2.3	Change Management	'Back in the day when you had ink drawings it would take a long time to correct that, but now, it's a matter of going into a model and making the changes, no need to recreate the model. It's easier to make the change but earlier you didn't do the change and you didn't have so much information in your drawings, it was like a concept or a guideline. More was done on site. 10 years ago, with ventilation, they solve it on the site, they find out on the site. Instead of working backwards now we can figure out the problems earlier' (Contractor) 'We have a business model we are trying to use to work differently but we see that we don't get what we need. When I say that, it's very easy to criticise the engineering group and architects but of course we have some challenges on our side as well for example, technical people will ask what sort of information do you need to run the building and we are not able to provide them with a list of data sheets. We are trying to now. We don't have a list for the metadata, pump first started for maintenance steps and guarantee period' (Public Client) 'Very often they only have their BIM manual, but the project manager has no clue what it says. The BIM manual from them don't tell you how to do it so we have to use our own. But we also have in the community a school or something who just want BIM…just because they heard about it. They don't have much knowledge about it, so there is also a lack of unity in developing the BIM strategy from the government, it also depends on the specific public client. For facilities management, they just think we put everything into a model and use it in 10 years' time' (Contractor) 'it's also about the speed of change that is going on now, requires that you develop faster so I think that's a mega trend so everyone is looking at the possible speed you can develop and improve. As the hourly rates go down and the contracts become more fixed price, it incentivises people to develop their own way of working' (Consultants) 'we also see that it is related to me and all my colleagues and the engineering teams and the construction teams, how are they measured, what is the success rate for them, what should they actually achieve to be a successful project manager, 90% is measured by money. In sub text that means do as little as possible, no one is measured by trying out and experience and add knowledge to the organisation based on trying something new…Convincing the market that this type of mentality is good for your business model is the next step' (Public Client)

Section	Factor	Quotation
5.4.2.4	Organisational Culture	'we can see that collaboration is not only a horizontal process but also a hierarchical process. For example, the use of technology such as BIM is not really supported well in the vertical manner, to address it very clearly to the board to make things better. This is one of the blurry things that make us blame culture. I think that if they get a chance to meet us in the middle management it would make it easier for them. When this happens in the part, we gave them a short Virtual Design and Construction (VDC) class they were really happy about it' (Contractor) 'I feel that it might also be that till they have seen the complete benefit, then it's going to be a problem because they will always perceive it as being risky to use it until its shown to benefit' (professional organisation) 'In a BIM related conference, head of a large contractor said that they were going to be digitalised and…you have these top managers standing there and promising everything. Then you come down to the projects…the project managers there will tell you that they know what he/she has said but that is not my world, I don't get any proper support from the main office, I don't have the knowledge' (Public Client) '…this company has read the specifications required which clearly states that it should be BIM Level 3 but it's not. Those that read this do not understand what it means but at the same time they write the contract we are obligated to deliver this but still don't understand even know they know that they need to do this. The management know that IT development is something we have to work on companywide, but they leave that to the middle managers who don't have enough resources or power to make much drastic change… Hierarchy is killing a culture and the information. They are just looking for numbers at the top because they are just business people, they have no clue of what we can achieve and the great potential. If they knew they will be working with it now. The years to come, we are starting to invest more in IT as the management have seen that. People who make the decisions are not the ones doing the job. The firm is too large to have a companywide workshop. If you look at the project, cost time planning you have all these different tasks which you have to do in a project, we don't want to have a better calculation programme, planning programme, faster Word documents. We are more into a combination, something systemic and that's what they don't understand and therefore there is this source of conflict and inefficiency. This is where we have to do the optimisation, looking at the whole picture to affect everything.' (Contractor) 'You are raising a very important perspective, a true understanding of culture and it's very hard to pinpoint what it is about. This is two different types of people,

Section	Factor	Quotation
		economical way of thinking and practical way of thinking. Also that you are in a large project where you have the power, when a person is able to act very non-productive way for the project in total, he/she has a position in his role and culture which gives him power and it looks like he is doing the right thing because he is giving you a large number of requirements and you are not able to fulfil that. Based on the perspective from the client, you are doing a real bad job and don't want to do the job, you are trying to avoid what you should actually do. This fundamental change in perspective is quite important to be aware of this. This implies that some efforts in dealing with technology is not the right priority from the lower side, you can improve the ice meetings but it's also other elements. Engineering vs management way of thinking is having some friction. This is raising some of these other elements such as the contracts and the personal part. You can have a project where you have a poor contract, but good people and therefore make it work well. Very good contract but you have persons managing it badly but goes okay. People are not aware of everything happening around them, there is a lack of communication. There is a gap that needs to be filled' (Contractor) 'Different cultures related to…whether they just want to focus on the change orders or are they actually up for solving the problem, the attitude is evident of the culture and is important, putting the project in the centre and collaborating, getting the most out of it but there is a paradox, we are in between the client and the contractors and designers, so it's our job to make the culture to give the client the best value for their money. We have to be aware of our own role, as a role model' (Project Management)
5.4.2.5.1	Communication	'My biggest learning is that the difficulty in doing this is in getting the people to actually know the scope, what is the deliverable because they come into projects and they are busy, have good ideas but they come to the meetings and they don't actually know what they should have done' (Project Management) 'worst things, if you are in an environment where I could get the blame, if its blame is relative to communication and if you are not understanding each other both have blame, if you understand each other than it's reducing the probability for error. If you are able to federate all the designs and can see a better way of communicating… BIM enables collaboration in a new way. You are supposed to look at a model in these collaboration tools, if the whole project is fixed to that idea, BIM enables new models for collaboration like IPD, VDC, ICE etc. it improves the communication.' (Professional Organisation)

Section	Factor	Quotation
5.4.2.5.2	Definition of Information	'…it's a challenge to use BIM as well, if you don't agree to what level of information you need or expect from the model, if you have a client or user who are presented a model and you haven't agreed on what to expect on level of detail or level of geometry or information, he is expecting that this is what I will get from the real construction but, often it isn't because you have just arrived to a certain degree of detail, that has been a challenge, which is why we are trying to standardise the level of information needed in the project stages' (Professional Organisation) 'you have the level of information defined then you could say that you are also paid for contributing to ideas to a design, that could be a way to order. Then it's also a way to remove the fear of adding more to help.' (Project Management)
5.4.2.5.4	Strategy Definition	'You can use people from outside, because they come from outside and they know how it is done in other companies, but you cannot just do a report and expect it to work, we won't use it. If we are not a part of it, we won't use it. If someone gives me a report, I will find something wrong with it and that is what I focus on. If I am a part of it, I will focus on the good things and try to improve it. I have to sell it to the company. Getting people to understand about the need for this kind of BIM strategy is the most stressful thing in my job, getting them to understand that it is an investment for the long term, and we cannot see the benefits straight away' (Contractor) 'We have a BIM strategy more or less like a checklist of what we are going to use the BIMM for, visualisation, collecting FM data, sorting out doors, keys, crowd simulation etc. so what we do is go through it what we need to use it for, and from that we get a good indication of what we need on the BIMM. Because that is one thing how we start up a project, another thing is how we are going to deal with information from A to Z. In some projects we only need to have a 3d model. We just need some sort of model. We define the BIM requirements, very dependent on the project leaders, complexity, what they need it for, durability of the project, maintenance, rebuilding of the project as it goes along. So, we have typical one project that will be an auditorium that we have defined a 3d model that's it. We have this mental process with the checklist that will give us an idea of the quality of the BIM' (Public Client)
5.4.2.5.5	Lean information	'…normally you think of BIM in a different way because you can collect all of the information the more details you have, the more happy the engineer is, you lose the focus, we think security is resolved by more information. E.g., detailed planning without doing a real planning, lot of information…You should be focusing more about the relevant information which is the lean information…if you

Section	Factor	Quotation
		look at the oil industry of platform rigging, with the AEC industry, different world, they look at the options at the beginning, the nuts and bolts because they don't want to waste time. They have a totally different scenario; money stream is different. They don't need lean information as much as we do…' (Project Management) 'We are working quite heavily on lean engineering, we are putting lots of money in Porsche consultancy, they are quite good at managing building cars even though they never build the cars themselves, they have helped us on a specific project, we are going to use the learning curve to work in a more complex project in Oslo. Do things differently' (Public Client)
5.4.2.5.8	Technical Competency	'Every project that uses BIM should have a BIM manager. Can have another role in the project, if it's a large project then it can be one person, but in smaller projects it can be a project engineer that takes up the role of BIM manager. It can be a site manager, or you hire the architect to be it. If I could choose, have our own BIM manager, on site then they use the model, we have some BIM managers on site and sometimes they do other stuff, but he can do other things too. He will have to show the people how to use the model. Sometimes we hire a BIM manager, couples of hours he federates the model, clash control but he does not understand what is happening in the project. Mixed role, support design manager, very often it's lacking in terms of skill, so I have to help them start up. We have a BIM manual in the company, how we use it, I go through it. I have to start them up' (Contractor)
5.4.3.1	Attitudes and Belief	'Different cultures related to what we said earlier, whether they just want to focus on the change orders or are they actually up for solving the problem, the attitude is important.' (Project Management) 'we had an engineering group that really wanted to do it. So it was to do with the attitude, it's of course to do with the contract form as well…What we see it's not necessarily a fixed correlation because it's extremely dependant on if you have someone in the organisation that really thinks that this is fun and we are going to have a proper BIMM. It's so important, we see out there that there is a large difference in the knowledge…What this old guy did was he went home and he had his son who was into gaming, he downloaded freeware of Solibri and he was sitting there learning how to navigate on Solibri. So, then he could help his colleagues, that's not because of the education, knowledge, but it's just because of the mentality' (Public Client)
5.4.3.3	Holistic understanding and thinking	'The business model is demanding that the market is not aware that they can think about the whole picture rather than just the specific use. Holistic view is needed…what

Section	Factor	Quotation
		we have gained by BIM is very very limited in the last 10 years…What we see as a potential huge benefit for total market, is the logistics part of it, if you can take a lamp, when going into production we can see that it will be tagged all the way with some sort of code like RFID. And they use they use tag to logistics to the owner but there it stops, when we receive it on site there the tagging stops, we don't use this information further…the person buying the bulb is different from the one choosing it' (Public Client) 'If we look at project as until it is established and built often that is what we look at, still we think it's too fragmented but the value, the big value is actually after that. So, you have too little part of the value chain to actually make a difference, or a monetise the collaboration format. FM is where the money is. It's like sub optimising, for the design team let's make incentive-based model but still the earnings are quite small. So, I think it's not such a big change, you need to think bigger than that' (Consultant) 'short term thinking, we need to manage the building…The contracts, fragmented mentality, 'this is mine', but then there is a general environment where everything is put together, it goes against the philosophy of how the contracts are made and the way people are behaving…this is the fundamental challenge' (Consultant) 'The management just think it's about big screens and smartboards. They don't see the overlapping parts of the IDDS model. Everyone is focusing on the tools and the disruption that the industry is having is putting more pressure on the process and the people because they are not really developing it with respect to the tools' (Contractor) 'to have this understanding to show the complexity and to see how much is going on is important, because there is a lack of understanding when you underestimate the complexity. Well it's not about technology. There are so many obstacles, we use such a small time in technology…<there are> organisation problems, competence problems' (Contractor)
5.4.3.4	Local industry culture	'The culture is that this has to be perfect because you cannot handle the critique, everyone is just waiting to criticise, so if you change it to giving ideas then it doesn't just need to be perfect and the main purpose is to get feedback… In one project the leader had to go because it was a public disaster and he should've known better and so that is not solving anything, you don't get a better building by doing that. The one person who was central to the whole project has to go then you are getting rid of any potential of learning about that… Every mechanism is set up to find the blame and to get rid of them, then you have

Section	Factor	Quotation
		solved it, but you really haven't…One of the things that could have helped with BIM implementation is the culture of its allowed to fail kind of culture more than now, it's more on digitalisation, if you want to require BIM if you don't deliver BIM you get the blame, its new so you are trying to build up competence in BIM as a vendor' (Professional Organisation) 'Engineering association, we are trying to organise a hackathon with them, but they are really nervous…They are not used to having a role of learning together, so it's more playing what do we get from it? That shows to me that there are some challenges in learning processes in construction projects, this is really unfamiliar territory for them' (Professional Organisation) 'the actual doers, the guy who designs electricity, he is usually doing it exactly. We don't have the scope, but he is making it exact… You need to iterate lighter footed' (Contractor) 'A friend was working with a US company…They couldn't use a project manager from the US, they tried to do it, but they couldn't. For example, they say you work in the weekend, or you get fired. But in Norway…its more socialistic…everyone is open, so the work ethic is different, and the project manager needs to be able to understand that…So they had a Norwegian project manager, so things changed. To get work done, in Norway, we ask not tell someone to do it' (Contractor)
5.4.3.7	Relationships	'…we were about to start a new building project, design team with the engineers from Norway and Denmark. Work with each other on a big hospital project, project management invited the group to a hotel and had team building, good food and drinks, and that helps a lot because you can talk and get to know each other. You bond in a good way.' (Contractor) 'It will always be better to know each other, personality of the people, the way they think, and you know their basic ideals, then you can skip the introduction, its more efficient you can go straight to the work. If you forget to do the introduction when you meet for the first time, you can often waste time because you are working for hours or days and then you realise that we are not on the same page' (Professional Organisation) 'The design build contracts are more suitable for open dialogue and transparency. I think the design bid build contracts and not much more professional but stricter to the contract. Maybe they have nice mood and it's fun to work but the contract is much harder there. It's not open for dialogue. So, when we cooperate with consultants, it's important to get trust so they can be honest and they can

Section	Factor	Quotation
		do and not can't do regarding to competence, time and everything and you shouldn't misuse it. Design bid build are more formal in its nature so it's less efficient in communication between contractor and owner, so there is less room for making common understanding' (Contractor) 'Yes, I think that firms do see the value in it, the problem is sometimes we have the start-up and not all the groups are contracted yet, maybe the most important ones are, but maybe the people on fire are coming in later' (Contractor)
5.4.3.8	Trust	'I think my experience is that the public clients are much harder and difficult to work with. Because the railway and road authorities they are kings, they are top of the hill, they know best and are very detailed in how they are running their projects, no trust between clients and contractors' (Contractor)